

metal finishing Journal

June, 1957



Vol. 3, No. 30 (New Series)

Editor: JOHN HOOPER Managing Editor: ALASTAIR McLEOD, F.I.M. Assistant Editor: E. H. LLOYD, A.I.M., A.C.T.(Birm.)
 Southern Area Manager: E. COLLIS Northern Area Manager: G. P. ELLIOTT Scottish Area Manager: T. H. SMITH
 Western Area Manager: E. J. SWEETING Eastern Area Manager: ERIC PERRIN
 Production Manager: R. J. LOVELL Circulation Manager: E. T. GRIFFITHS Publisher: H. J. DWYER

Official Organ of the INSTITUTE OF VITREOUS ENAMELLERS



President:
C. R. WHEELER, C.B.E.

Chairman:
W. THOMAS

Secretary:
J. D. GARDOM
John, Gardom & Co., Ripley, Derby
Telephone: Ripley 136

Published on the 15th day of each month by

INDUSTRIAL NEWSPAPERS LIMITED

Chairman and Joint Managing Director:
 Barrington Hooper, C.B.E.
 Joint Managing Director and
 Commercial Director:
 F. Barrington Hooper, B.A.
 Director:
 F. R. Lewis
 Director and Secretary:
 E. G. Weston

JOHN ADAM HOUSE
 17-19 JOHN ADAM STREET
 ADELPHI, LONDON, W.C.2

Telephone: TRAfalgar 6171 (P.B.X.)
 Telegrams: Zacatecas, Rand, London

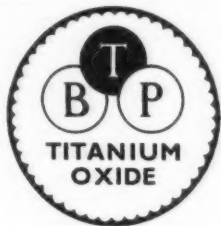
Subscription Terms:

Home and Overseas 24s. per annum
 prepayable
 Single copies 2s. (2s. 4d. post free)

THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

Contents

	PAGE
"As The Die Is Cast"	227
Talking Points	228
"Platelayer"	
Experiences and Problems in the Surface Treatment of Zinc and Aluminium Die Castings	229
H. Ruegg	
Methods Used in the Performance Testing of Paint —Part 2—Adhesion	241
W. V. Moore, B.A.	
A Modern Plating Shop for Precision Equipment at the works of Rank Precision Industries Ltd. ...	243
Institute of Metal Finishing Conference Report (concluded)	247
Finishing News Review	257
Plant, Processes and Equipment ...	263, 264, 266, 268



*The best grades
for vitreous enamels*

Giving—improved acid resistance
and greater opacity,
increased brightness
and better gloss and
gloss retention



is made in Britain by
British Titan Products Company Limited
the largest Titanium Oxide manufacturer
outside the United States

Factories at Grimsby and Billingham and at Burnie, Tasmania
Agents in most principal countries

**BRITISH TITAN PRODUCTS
COMPANY LIMITED**
COPPERGATE
YORK

AS THE DIE IS CAST

ONE of the major causes of complaint voiced by metal finishers, particularly those who are engaged in contact or "jobbing" work, is that they have little or no control over the design or material properties of the articles they are called upon to finish.

It is, of course, to be expected that in the case of a finish proving to be unsatisfactory in service, the man responsible for applying it should endeavour to place the blame for the failure on some contingency not within his control, rather than to admit his own technique to have been at fault. Thus it is often found that the reason for faulty electrodeposits lies in the faulty design of the component, or the presence of undesirable constituents in the surface of the base metal; similarly porosity in castings is blamed for any inadequacy in vitreous-enamel coatings on cast iron.

It should not be assumed when such reasons as these are put forward, that they are always unjustifiable and baseless attempts to "pass the buck", any more than it is true that all metal finishes are applied with scrupulous impeccability. The truth, as is so often the case, has some basis in both sides, in that responsibility for the production of an adequate finish, particularly where such exacting processes as electroplating and vitreous enamelling are concerned, rests very nearly as much with the designer and manufacturer of the component to be finished as it does with the applier of the finish himself.

For this reason those whose activities are in the finishing department of a large manufacturing concern are regarded as being in a more favourable position in that they can, at least in theory, exercise some influence over the production of the components with which they have to deal.

It is very much in the interests of sound finishing that the nature of finish required, and any special requirements it may have, should be taken into consideration at the very earliest possible stage in the planning of a product, so that proper attention can be paid to making the application of the selected finish an economic possibility. This applies with particular force in the case of zinc-alloy die castings. The versatility of the die-casting process and the suitability of zinc alloys for casting by this method have led to the wide-spread adoption of zinc-alloy die castings in numerous applications. At the same time it has been appreciated that the production of an adequate nickel-chromium plated finish on a die-cast zinc surface presents a number of specialized problems, some of which have not even yet been fully or satisfactorily elucidated.

At a recent Conference in Paris many aspects of die-casting practice were discussed by a large international gathering, and at none of the sessions was interest more keenly evident than at those devoted to a consideration of finishing practice. One of the papers presented at this Conference is published elsewhere in this issue, and reference is made therein to many aspects of the subject on which further investigational work is necessary.

The premature failure of plated finishes on zinc-alloy die castings has in the past brought into disrepute not only the plating industry, but also the die-cast products themselves. If confidence is to be restored energetic action is needed to evolve a finishing procedure which will be at least comparable in service performance with those used on other metals.

Talking Points

by "PLATELAYER"

TOPICAL COMMENT
FROM THE MAIN
LINES AND SIDE
LINE OF METAL
FINISHING

I.M.F. IN S.W.

THE inauguration of yet a sixth Branch of the Institute of Metal Finishing, in Bristol, means that the Institute will be holding some 60 meetings and a Conference next Session. This involves presenting about 70 papers—a truly formidable task for a body with a membership of little over 1,000. It is no doubt too much to expect that they will all be good!

GILDING THE LILY

EVERY so often someone rediscovers the virtues of combining electroplating with heat treatment, usually with the object of causing different layers of metals to diffuse into one another to improve corrosion-resistance. Some years ago we heard a great deal about Corronizing, a process in which thin coatings of zinc and nickel were alternately plated on steel articles, and the finished product heat treated at a low temperature. Great improvements in corrosion resistance were reported. Quite recently, similar claims have been made for the heat treatment of articles plated with multiple alternate layers of nickel and chromium.

The objection to all these processes is that the additional operation is a costly one to carry out and can only be warranted if the improvement is really striking, and it is very doubtful if this is really the case. Also, heating inevitably impairs the appearance of the finish.

The latest addition to the plating heat-treatment series comes from the Battelle Institute who report that molybdenum in turbine blades can be protected from oxidation by nickel and chromium plating, followed by a thin layer of gold, a further nickel and chromium deposit, and a heat treatment operation. It appears that the gold interlayer greatly increases the protective value of the nickel-chromium deposits at elevated temperatures. Of course, the cost angle is not so important in this application, but how about a gold layer under the chromium on a car bumper?

PUTTING BEANS INTO PLATING

CONTRARY to general opinion, there is little difficulty in finding substances which, when added to a plating solution will make the deposit more or less bright. Many organic materials under appropriate conditions will do the trick. The real problem is to find a material or materials which will work over a wide plating range and be readily

controllable and not cease to function suddenly and inexplicably. This is a much more difficult matter. Whether these requirements can be met consistently by organic materials of natural origin and uncertain composition is a moot point. The recently published work on the effect of wood distillates on the brightening of tin deposits is a typical case, as changes in distillation conditions or the type of wood used can give varying results. A similar use of an ill-defined and not readily controllable material is mentioned in a recently published British patent, in which an extract of coffee beans is claimed as a brightener for zinc deposits. If "Nescafe" or "Chico" prove satisfactory for the purpose, we may yet find the grocer in the role of plating trade supplier.

JOINING THE CO-OP.

A GROUP of seven small-scale footwear manufacturers in the East Midlands who are normally in competition with each other have jointly decided to operate a sole-vulcanizing unit on a co-operative basis, since it would be uneconomic for each firm to acquire its own machinery for this purpose.

This is an interesting development since it provides a means by which small producers can obtain the benefits of modern high output machines and thus be able to compete with larger companies. Only a modest capital outlay is required from each firm by this method.

We might yet see groups of metal finishers acquiring automatic plating machines, conveyorized enamelling ovens or electrostatic spray equipment to deal with their longer runs of work. But probably our industry is too individualistically-minded for this to happen.

WHAT'S IN A NAME?

NAMES of companies can sometimes be misleading, but they can also tell much about their history. The Birmingham Battery and Metal Co. for instance, has never made batteries in the whole 120 years of its existence. The word "battery" in the title refers to an old method of making pans from brass sheets by battering them with tilt hammers. It is also no use going to the Victoria Blower Co. for a fan; it does not make them or anything else, the function of the company being to supply racecourse information to bookmakers.

Experiences and Problems in the SURFACE TREATMENT OF ZINC AND ALUMINIUM DIE CASTINGS*

By H. RUEGG

Introduction

This treatise describes the working methods employed by Injecta A.G. in the electrochemical treatment of zinc and aluminium pressure die castings. The various problems met with in practice are discussed, and attention drawn to some new methods of surface treatment.

This work, while making no claim to completeness in respect to the literature cited, is intended as a contribution to the discussion of modern methods of surface treatment of zinc and aluminium pressure die castings.

MECHANICAL PROCESSES

Grinding and Polishing

IN mechanical surface treatment care must be taken to remove the thinnest possible layer. The thick casting skin should not be ground away, as otherwise any subsequent treatment may be made more difficult due to porosity in the metal surface.

The mechanical processes covered by this treatise refer only to fine grinding and polishing, as any coarse grinding is assumed to have already been carried out as part of the fettling process (removal of flash and gating protrusions).

The object of fine grinding is to remove small surface defects, such as cold shuts and inequalities due to die wear, or at any rate to make them less conspicuous. Grinding with grinding discs has now been largely superseded by the so-called contact grinding, involving the use of abrasive belts and backstand grinding equipment. The old forms of grinding discs were covered with abrasive by rolling the glued side in a layer of abrasive powder. This method however, gave a haphazard orientation of the individual grains, and the maximum cutting power was only achieved after the introduction of the now universal electrostatic method of covering. Mostly electro-corundum (electrically-fused alumina) is used for the fine grinding of zinc and aluminium pressure die castings.

Zinc pressure die castings destined for subsequent electroplating are normally first subjected to a fine grinding operation. The contact discs or wheels, of 350 mm. diameter, are built up of radially arranged layers of calico, fairly hard for flat surfaces, as they maintain the abrasive belts sharp for a longer period. The contact discs with their superimposed grinding belts of 350-cm. length revolve at 2,000-2,500 r.p.m., giving a belt speed of 36.5-45.5 m. per sec. According to the nature of the work, belt widths of 50 or 75 mm. are used.

Polishing grease is used in grinding, sufficient being used to keep the belt supple and to avoid scratches on the surface of the castings. For the fine grinding of castings without flat surfaces, softer contact discs are used, made up of loosely folded polishing mop discs. Soft contact discs enable highly flexible belts to be used, which adjust themselves to the contour of the articles being ground, using only slight pressure. For the fine grinding of zinc alloys, grade 240 abrasive is used which gives a surface suitable for subsequent polishing. Certain intricate parts can, however, only be successfully fine ground with blunted grade 240 belts, as by this means only thin layers of the casting skin are removed. Trials have in one case shown that removal of about 2½ mg. per sq. cm. in the fine grinding operation is equivalent to a reduction of about 7 mg. per sq. cm. in the polishing operation.

Aluminium pressure die castings are today also fine ground exclusively by the contact method. The built-up contact discs which are used are of 350 mm. diameter, made to take abrasive belts of 50, 65 or 75 mm. width, though in special cases narrower discs are used. Grooved rubber contact wheels are not favoured, as the whining noise which they emit is disturbing to the operators. By using a double-grooved wheel (X-grooving) the unpleasant noise can, however, be largely eliminated, and such wheels hinder the rapid deterioration of the grinding belts and lead to a more rational utilization of the material. Aluminium castings of intricate shape can also be

* A paper presented to the International Pressure Die Casting Conference, Paris, May, 1957.

fine ground, using soft folded contact discs, grease being again recommended. Experiments with lubricating oils for this purpose have not had good results. The speed of the contact discs is 1,900-2,400 r.p.m., which with a disc diameter of 350 mm. gives a surface speed of 35-44 m. per sec. Aluminium pressure die castings destined for subsequent hand polishing are best fine ground using grades 180-240 abrasive, though somewhat coarser abrasive (grades 100-150) should be used for parts to be finished by barrel polishing (tumbling).*

In addition to contact grinding, limited use is also made of belt grinding equipment, using endless moving belts (surface speed about 10 m. per sec.) The life of these abrasive bands depends largely on the composition of the alloy. In one case it has been noticed that an alloy high in iron, resulted in a longer working life of the abrasive belt, which was attributed to the fact that an aluminium alloy low in iron causes rapid smearing of the belt, and more pressure must be exerted in consequence. This causes a rise in temperature and increased load on the belt, which gives way prematurely at the glued joint.

For very fine grinding without undue removal of material, the so-called *Vonnegut* grinding discs give good service. These consist of disc brushes of 300-400 mm. diameter, 50-100 mm. wide, interleaved with grooved linen discs covered with Carborundum of grade 100-120; speed of rotation 550-750 r.p.m. Such linen discs, supported by brushes, ensure cool-running and soft grinding, which is particularly suitable for the fine grinding of surfaces with raised lettering.

The polishing of zinc and aluminium pressure die castings is done in the Injecta works exclusively with mops made of cloth discs. Zinc alloys, with their relatively low melting point, require soft, loosely woven cloth discs of 350-mm. diameter rotating at 1,900-2,400 r.p.m. The individual discs are normally roughened on one side only, but where particularly soft discs are required, they are roughened on both sides. In building up the mops from discs roughened on one side only, care should be taken that rough surfaces lie against rough surfaces and *vice versa*, thus: smooth/rough, rough/smooth, smooth/rough, etc., as this results in less wear than when the contrary arrangement is adopted.

Alternate layers should also be arranged with the run of the cloth (weft) at different angles, in order to secure a more even wear of the discs. When polishing zinc alloys, loose unstitched discs are usually employed, as stitched discs are too stiff. A number of different polishing compounds

is in use, the choice largely depending upon the preference of the individual operator. A cleanly polished casting with the minimum of adhering polishing compound is essential for the subsequent preparation for electroplating. For this reason, it is sometimes advisable to finish off with a clean, soft cloth mop.

In addition to the unstitched resilient discs, loosely folded discs embodying corrugations are sometimes employed, as these radial corrugations give added pliability and ensure a certain amount of ventilation to the surface being polished. They also enable a more energetic technique to be employed and are mainly used on large castings, not easily deformed by high pressures. The speeds of mops with discs of 350 mm. diameter used for polishing aluminium are 2,400-3,000 r.p.m.

The principal problems encountered in grinding and polishing pressure die castings are connected with improving efficiencies. Even European foundries with their relatively small production runs, should consider whether it would not pay in special cases to install semi-automatic grinding and polishing plant. The very high requirements of the European users of pressure die castings in regard to surface finish can, however, usually only be fully met by very expensive automatic or semi-automatic machines, at any rate where complicated shapes are involved. A better way of meeting the situation is probably by the use of the polishing fluids that have recently been introduced in the U.S.A.

Grinding and polishing are among those operations that have so far not been the subject of systematic study, a great deal being still left to the "feel" of the operator—it is in fact more of an art than a science. The theory of grinding is still in the embryo stage, but a recent study⁽¹⁾ into the sequence of events that take place in grinding represents a valuable contribution to the critical analysis of the fundamentals of the subject. The high surface temperatures which occur in polishing probably lead in some cases to incipient fusion of the surface layers and to their recrystallization. Complete knowledge is also lacking about the nature of the surface layer (the so-called Beilby layer) and the influence of operating conditions on its formation and properties⁽²⁾.

Sand Blasting

Zinc and aluminium pressure die castings are usually sand-blasted to form a roughened surface to which paint will adhere. The usual screen analysis of the quartz sand used is approximately 60 per cent. by weight 0.3-0.6 mm., 20 per cent. 0.2-0.3 mm., 15 per cent. <0.2 mm., remainder >0.6 mm. The pressure used is 1½-3 atmospheres and hard-metal nozzles are used, the castings being arranged on a rotating table of 1½ m. dia-

* The new barrel grinding techniques are only applicable in a very restricted sense if importance is attached to a fine surface finish, particularly when fine tolerances and small radii on corners are required.

meter. The nozzle is held about 20-30 cm. above the table and is given a circular movement during the sand-blasting operation. After 2-4 rotations of the table the articles are usually sufficiently roughened. Intricate castings are usually sand-blasted individually by hand at a distance of about 20 cm., the nozzle being manipulated until an even distribution of the roughened surface has been attained.

Sand-blasting results in a matt surface, very sensitive to finger marks and the like. A new method of treating aluminium castings involves the use of aluminium granules⁽³⁾ in place of sand and articles treated by this method have a pleasing, bright matt surface.

Barrel Polishing

There is a large literature dealing with barrel polishing or tumbling⁽⁴⁾. Various factors are involved in the mechanism of this method of surface treatment, the more important variables being shape and size of barrel, material used as lining, arrangement of the subdivisions inside the barrel, nature, shape and size distribution of the filling material, degree of filling, ratio of weight of parts to weight of filling material, amount and composition of the polishing fluid and the speed of rotation and duration of run.

At Injecta, barrels are made of beech-wood and are cylindrical, rotating at 40 r.p.m. The filling material is steel shot of 2-10 mm. diameter, and occupies from one-third to one-half of the inside of the barrel, according to the surface finish required. Low filling causes a more "hammered" appearance, while higher filling results in a scouring action of the tumbling and sliding shot and produces a fairly smooth surface. However, any surface defects in the castings are liable to be

shown up by this treatment, and large castings must be firmly secured to the barrel by some means to avoid damage through mutual collisions due to turning and rolling in all directions inside the barrel.

Best results have been obtained with soap as the principle ingredient of the polishing fluid. Experiments with substitutes, such as phosphates and carbonates, have so far not led to satisfactory results. In most cases running time is between 20 and 30 minutes.

METHODS OF APPLYING ORGANIC COATINGS

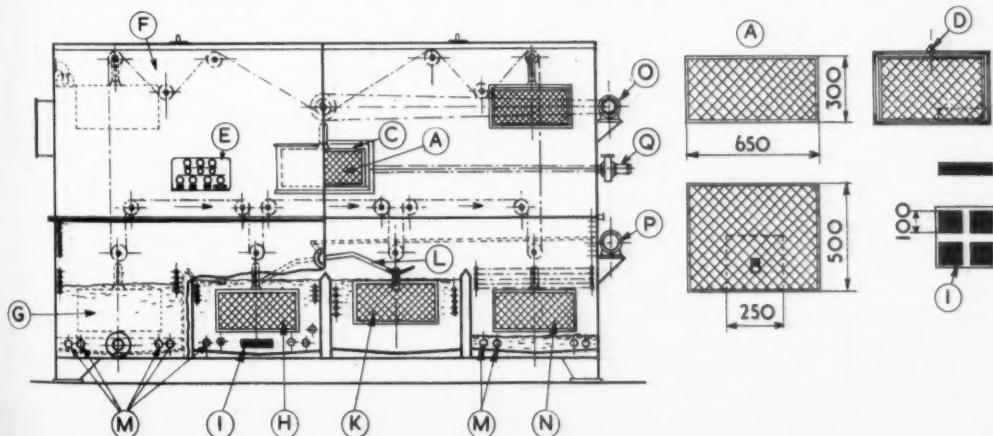
Cleaning and Degreasing

The cleaning and degreasing of mechanically pretreated castings preparatory to painting or electroplating must be carried out very thoroughly, as upon this operation depends the proper adhesion of the coating and its value as a protection against corrosion.

The degreasing of pressure die castings at Injecta is done with perchlorethylene in automatic degreasing plant supplied by Technochemie A.G. in Zürich. In this plant ordinary greasy articles, for which no further surface treatment is envisaged, can also be degreased. One type of plant is fitted with rotating cages, in which the parts are subjected to three successive baths of circulating perchlorethylene at 115-120° C. This automatic degreasing plant is particularly suitable for castings which have been subjected to some sort of machining operation (drilling, screw cutting, etc.). The tumbling action of the cages helps in getting at adhering swarf in holes and pockets. On the other hand the method is not altogether suitable for the degreasing of fragile, thin-walled castings.

For zinc and aluminium pressure die castings that are required to be completely free from

Fig. 1.—Diagram of ultrasonic cleaning equipment. The lettered sections are described in the text.



scratches, a modern plant is now available fitted with an ultrasonic device which reinforces the action of the degreasing fluid.

In recent years ultrasonic methods of cleaning have been finding increasing favour in industry. A quartz crystal, energized by an H.F. generator, or certain synthetic materials with piezoelectric properties, such as barium titanate, have the property of converting electric vibrations into mechanical ones. These high-frequency vibrations are transmitted to the adjacent medium and are propagated through it as waves.

These ultrasonic vibrations materially increase the cleaning power of the fluid, as they set up high-frequency vibrations on the surface of the articles being treated, causing small dirt particles to be literally flung off the surface. The particular advantage of ultrasonics is that they enable inaccessible corners and pockets to be reached, this being frequently reinforced by cavitation effects, depending upon the frequencies used.

The ultrasonic equipment in use at these works is constructed as shown in Fig. 1. All articles to be cleaned are put into cages A (650 mm. wide, 300 mm. high and 500 mm. deep). The castings which are to be subjected to ultrasonic cleaning (mostly polished zinc die castings intended for subsequent electroplating) are placed in special frames in space B. Care should be taken in arranging the different layers to ensure that the top layers come under the action of the ultrasonic waves. Some of the ultrasonic energy is lost by reflection, and the further the articles are away from the source of vibration, the less is the effect. When working without ultrasonics the opening B is closed by means of a perforated sheet. The cage containing the parts is put through the feeder opening C and suspended in the frame D. The plant is started up by a press button on the control panel E. By means of a moving chain the cage travels *via* the station F to the cleaning bath G which is filled with perchlorethylene and heated by means of immersion heaters to 100-120° C. In the next bath H the ultrasonic equipment is installed*.

The four barium titanate vibrating heads (surface of each 10 x 10 sq. cm.) are situated in the perchlorethylene bath, which is maintained at 65-70° C, the cleaning fluid also acting as a cooling medium for the ultrasonic power source. Both in the bath H, as well as in the cold water rinsing bath K (maintained at 30° C) the cages are subjected to an oscillating movement. After rinsing the parts are dried in hot perchlorethylene vapour (Bath N) and finally removed *via* the ventilated opening C.

* Output of H.F. Generator	...	...	6.3 kW.
Ultrasonic Output, normal	...	...	2,000 W.
maximum	...	...	2,900 W.
Ultrasonic Frequency	...	...	400 kHz (kilohertz)

Experience has shown that a combination plant, arranged for operation either with or without ultrasonics, involves a certain amount of compromise. For instance the ultrasonic equipment cannot be used to full capacity, and with a throughput of 10,000 articles per day there is considerable contamination of the cleaning fluid. The mechanical contaminants (swarf, etc.) may also cause some interference with the working of the ultrasonic plant. These contaminants can, by periodic filtering of the baths G and H, be largely got rid of. The efficiency of the ultrasonic equipment could also be improved by the fitting of rotating cages. In this case the more delicate polished castings would need to be fixed to the frames, or the pivots of the rotating cages could be vertical. On the whole, however, intricate, brittle castings are best treated in a separate ultrasonic cleaning plant.

Painting

Pressure die castings, after degreasing and roughening by sand-blasting or phosphating, can be painted by conventional methods, usually by spraying in ventilated spray cabinets, using any of the common organic media based on natural or synthetic resins, linseed oil, nitrocellulose, etc., according to the use to which the articles are to be put and the requirements regarding corrosion resistance; the choice is best made in consultation with the paint manufacturers⁽⁶⁾.

The new method of hot spraying has also been successfully employed by Injecta A.G.⁽⁶⁾. In addition to a saving of 25 per cent. on thinners and a reduction of some 10 per cent. in application time, there is also a reduced loss of paint in the spraying booth.

The electrostatic method of spraying⁽⁷⁾ involves high investment costs and can only be made to pay when very large numbers of castings are involved.

CHEMICAL SURFACE TREATMENT

Phosphating

In phosphating, the articles are treated to give a rough, porous surface which will give a good anchorage for subsequent paint application.

The phosphating process is considered as being most suitable for zinc die castings. An essential prerequisite for the formation of a uniform phosphate film is absolutely complete degreasing previously. The phosphating is carried out in a bath heated to 90-98° C and containing as principal ingredients secondary zinc phosphate, free phosphoric acid and zinc nitrate as accelerator. From time to time iron parts are treated in the bath, resulting in a certain addition of iron, which has the effect of increasing the thickness of the phosphate layer on the zinc alloy⁽⁸⁾. Any superfluous iron can be precipitated as iron phosphate by the addition of nitrite. Time of immersion in the



Fig.

phosph
rinsing
hot wa

In d
of chro
articles

Etching

Alum
silicon
barrel
tint it
surface
picklin
acids.
picklin
being
exhaust

The
(supp
P.V.C

conta
The
racks
the e
by th
back
polye
with
the
vapo
mean
reser
comp
whic
liqui
gase

T
20-4
runn
shor

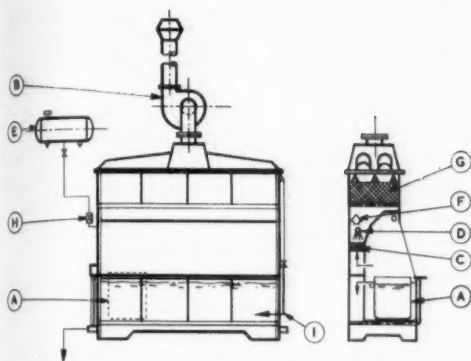


Fig. 2.—Pickling tower for aluminium die castings.

phosphate bath is about two minutes. After rinsing in cold water the articles are plunged into hot water for a few minutes and then dried.

In drying the same problems arise as in the case of chromium-plated articles (*vide infra*). Aluminium articles can also be phosphated (⁹, ¹⁰).

Etching, Chemical Brightening and Colouring

Aluminium pressure die castings containing silicon can be given a bluish bright surface by barrel tumbling. However, to produce a silvery tint it is necessary to remove the silicon from the surface layer. This can best be accomplished by pickling in a mixture of hydrofluoric and nitric acids. This should be carried out in a well ventilated pickling tower (see Fig. 2), particular attention being paid to the neutralization of the poisonous exhaust gases and of the toxic waste water.

The pickling tower, made of hard P.V.C. (supplied by Colasit A.G., Wimmis) contains a P.V.C. pickling vat with polyethylene lining, which contains the hydrofluoric acid/nitric acid mixture. The aluminium die castings are suspended from racks and dipped into the acid bath, resulting in the evolution of acid fumes which are sucked away by the fan B and conducted through the slits in the back wall to the absorption bed C filled with polyethylene contact material. This bed is sprayed with water from flat nozzles D which takes up the hydrofluoric acid vapour. The nitric acid vapours are converted to nitrate and nitrite by means of ammonia which is drawn from the reservoir E to the distributor F, the reaction being completed in the activated carbon filter G, through which the liquid is allowed to trickle. The waste liquid is practically free from acid and nitrous gases.

This pickling or etching process takes about 20–40 seconds and the articles are then rinsed in running cold water, plunged into hot water for a short time and finally dried, free of specks.

The pickling or etching process is exothermic and a bath temperature of 30–40° C is required for an even chemical attack. The treatment of runs of castings results in a rise of temperature of the bath, and sometimes the P.V.C. polyethylene containers cannot be kept at the right temperature by the rinse water. One way of getting over this difficulty is to suspend thin-walled flexible bags of polyethylene, filled with cold water, in the pickling tank. It is noticeable that material previously polished shows a lighter colour after treatment than unpolished castings. The same phenomenon is noticeable in articles that have been barrel polished. At the same time the difference in colour between polished and unpolished specimens which have been previously pickled is less noticeable than on pickled specimens, after barrel polishing.

Zinc die castings frequently leave the die with a very smooth surface and it seems a pity that such articles cannot be given a high polish by a simple dipping operation. In recent years several processes have been put forward for the chemical brightening of such castings⁽¹¹⁾. Injecta have carried out researches along these lines, but it has been found that treatment with the solutions put forward (based mainly on chromic acid) gives a rather bluish iridescent brilliance on zinc die castings. By suitable modifications of the process, however, a surface resembling chromium plate can be produced, but only with a sacrifice in corrosion resistance. Good results have also been obtained with a mixture of chromic and hydrochloric acids⁽¹²⁾. But these brightening fluids have the disadvantage of not being very permanent, and up to the present no chemical brightening process has been found capable of imparting a uniform film over large areas, as the surfaces of castings always contain differences of macro-structure, which the chemical treatment brings out. It is worthwhile considering, however, whether such chemical processes might not take the place of mechanical polishing for castings which are to be subsequently electroplated.

The wish is often expressed to be able to use a chemical process for the colouring of zinc die castings. Such coloured films, however, impart no corrosion resistance and are mainly used on cheap mass-produced articles; the corrosion resistance can of course, be improved by the subsequent application of a thin coating of transparent lacquer. The range of colours is very limited, black being the most easily obtained⁽¹³⁾, for though there are on the market prepared salts for making up the colouring baths, experience has shown that it is difficult to get an even colour, free of blemishes, particularly with intricate shapes. Brown tones can however be produced on copper-plated zinc castings by the use of polysulphide solutions. The

partly oxidized thin copper film is spread over the surface by means of rotating soft wire brushes and finally fixed with a coating of clear lacquer.

ELECTROLYTIC PROCESSES

Chromium Plating over a basis of Copper/Nickel

Practice at Injecta is that the polished zinc die castings are first degreased with perchlorethylene in the degreasing plant, attached to suitable racks. The time that elapses between polishing and degreasing should not be too long, as in course of weeks a change takes place in the nature of the surface of polished articles, which may result in poor adhesion of the plating and the formation of blisters. These defects are of course, still more noticeable if the parts have in transit come into contact with dirt of any nature (finger marks, etc.).

Castings which have been treated to give a special decorative matt finish can, without further treatment, be put straight into the plating bath and fixed to the racks, which are covered with an acid- and alkali-resistant synthetic material.

In the U.S.A., in place of degreasing with perchlorethylene or trichlorethylene, special emulsions are frequently used. Extensive trials have been made with these baths, but the conclusion has been reached that this method of degreasing is not suited to conditions ruling in Europe, where organic liquids still hold the field.

The efficiency of the emulsion degreasers depends largely upon the degree of soiling to which the polished articles have been subjected, and to the intensification of the physical-chemical action of the cleaning fluid by vigorous stirring of the baths. Relics of charred polishing paste, mixed with metallic residues (swarf), are very difficult to wrinkle out of odd corners and recesses, though this can be assisted by ultrasonics.

The hand-operated baths and rinse tanks are arranged in the following order:—

1. Electrolytic degreasing
2. Rinse tank
3. Rinse tank
4. Neutralizing bath
5. Rinse tank
6. Copper strike bath
7. Bright copper bath
8. Drag-out recovery tank
9. Rinse tank
10. Neutralizing bath
11. Rinse tank
12. Bright nickel bath
13. Rinse tank
14. Rinse tank
15. Hot water rinse

For chromium plating

16. Chromium bath
17. Drag-out recovery tank
18. Rinse tank
19. Rinse tank.
20. Hot water rinse

The electrolytic degreasing is carried out anodically, using a sheet steel cathode in a bath based on carbonate-phosphate-silicate-hydroxide. Current density is $2-2\frac{1}{2}$ amp. per sq. dm. at a temperature of about 75°C with time of immersion 20-30 seconds. The cyanide-free electrolyte used gives a life of 30-40 amp.-hours per 100 litres.

In the course of time the parts situated in the area of maximum current density show some spotting, but this can be largely suppressed by the addition of sodium thiosulphate⁽¹⁴⁾ though at this stage it is better to renew the electrolyte.

Expert opinion seems to be divided as to the best way of carrying out electrolytic degreasing. Whereas in Europe cathodic, or at the most cathodic/anodic working is most common, the Americans appear to favour anodic degreasing and the author has had satisfactory experience with the latter. The danger of over-degreasing with this system is much less, while the risk of hydrogen absorption on the surface, giving rise to blisters, is also avoided. The electrolyte contains a wetting agent (surface active agent) which accelerates the removal of the residues from the polishing operation. This wetting agent, by reducing the surface tension, also minimizes the drag-out losses.

The alkaline degreasing fluid remaining on the surface must be completely removed by the subsequent rinsing operation, too little attention being usually given to this. Simple spraying with jets of water under high pressure is not as effective as complete immersion in the rinse water, which should at the same time be strongly agitated. A good method is to supplement the rinsing water with a high-speed water jet (under the water), as the entrapped air in such a system results in a thorough circulation of the rinse water. In hand-operated plants less difficulty arises on this score, as the castings can be shaken vigorously to secure the necessary turbulence on the surface of the articles. It is considered important to repeat the rinsing in a second rinse bath, as the alkaline film containing the wetting agent has a way of lingering fairly firmly to the surface of zinc. Such double rinsing is particularly indicated for castings with a rough surface resulting from mechanical treatment and destined for subsequent electroplating.

Even with the most thorough rinsing, a further neutralization stage is required. Energetic agitation for 5-10 seconds in a 0.5-0.75 per cent. sulphuric acid solution will get rid of the last traces of the residue from the degreasing bath. If however this

acid dip is too prolonged, or the strength of acid is too high, there is a risk of nascent hydrogen forming on the surface of the casting and of some surface etching.

In this way the brilliance of polished castings may be adversely affected, and with it that of the subsequent copper deposit and even in some cases of the overlying nickel deposit; there is also the risk of blister formation. A further objection to overdoing the acid dip is that the flow lines of the casting are thrown into relief, particularly on large flat surfaces. Such a casting structure, brought into prominence by the acid treatment, may be transferred to the overlying copper deposit or even right through to the nickel, resulting in uneven brightness of the latter. The zinc castings should only remain in the acid bath until there is a very slight evolution of hydrogen. Phosphoric acid is claimed to exert a less intensive and more even attack on the castings⁽¹⁵⁾.

The use of phosphoric acid is also recommended as a cure for the formation of the unwelcome etching figures. The smoothing effect of the phosphoric acid bath also reinforces the brightening action of the copper and nickel baths⁽¹⁵⁾.

After degreasing and neutralization the articles are transferred to the copper strike bath. Working with a current density of about 2 amp. per sq. dm. the articles are kept in the bath for 20-40 seconds without agitation at a temperature of 50° C and with a very low cathodic current efficiency. The potassium cyanide bath contains about 7-10 gm. per litre of copper, the content of free cyanide being about 10 gm. per litre of KCN. It should be emphasized that the copper strike bath is only to be recommended in those cases where, owing to the low content of free cyanide in the copper plating bath proper, there is a risk of copper precipitation when putting in the zinc castings. This copper may form a loose layer of poor adhesion, which adversely affects the quality of the electrodeposit. The contents of the copper strike bath must be periodically filtered, although in general suspended impurities do not seriously interfere with its operation as the layer of copper deposited is very thin.

The racks, which are suitable for articles with an average surface area of 15 sq. dm., are now hung in the bright copper bath. The composition of this organic bath, based on potassium cyanide, is basically as follows:—

45-50 gm. Cu per litre ... up to 60 gm. K_2CO_3 per litre.

25-40 gm. KOH per litre. 20 gm. free KCN per litre.

The addition of a wetting agent, in combination with a brightening medium, results in a reduction of the surface tension to about 40 dynes per cm. The tank, heated direct with electrical tubular

heaters arranged horizontally on the bottom of the tank, is lined with wired glass.

This type of lining was chosen in order to avoid the creation of stray currents between the tank and the outside of the tubular heating elements. The strongly alkaline bath at the high working temperature has a slight attack on the surface of the glass but no adverse effect of the dissolved silicates on the copper deposit has been detected. Lining the tank with rubber would theoretically be preferable to glass, but the high working temperature makes the maintenance of close contact between the tank and the lining difficult and failures occur through swelling of the rubber lining, causing it to come away from the tank wall.

Experience with heated copper baths has shown that they are best heated indirectly. The working temperature is 75-85° C, and the cathode rods are agitated at a speed of 330 cm. per min. The average current density is about 2 amp. per sq. dm., with a cathodic current efficiency of practically 100 per cent. In the early days higher current densities (up to 6 amp. per sq. dm) were used but intricate castings cannot by this means be given a uniformly bright deposit, as some places will lie outside the range of maximum brightness. The plant is designed to give an average thickness of deposit of $7\frac{1}{2}$ -8 microns.

The electrolytic-copper anodes still contain troublesome inclusions, which are sometimes carried over to the electro deposit, and this not only reduces the corrosion resistance, but may spoil the appearance of the finished article. The use of the usual cotton anode bags certainly prevents the formation of rough patches, but these thick bags lead to imperfect renewal of the anode film and resultant polarization of the anodes. The content of free cyanide in the copper bath is thereby increased and the brightening range is shifted towards areas of lower current densities. The impoverishment of the bath in respect to copper content must be rectified by the addition of fresh copper cyanide. This method of working is inefficient as the bath can only be kept in equilibrium by repeated analytical control, while the replacement of the copper can only be effected by additions of the expensive copper cyanide. After lengthy experiments it has been found possible to prevent the polarization of the anodes by enclosing them in bags with a mesh of 1,000 per sq. cm. (thread thickness 0.1 mm.) and at the same time materially reduce the incidence of rough patches on the copper deposit, but this problem of roughness has not yet been completely solved. The question arises whether the use of built-in diaphragms to separate the anode and cathode zones^(16, 17) would pay for the small hand-operated plants common in Europe, as the successful working of such diaphragms depends upon very thorough filtration. In recent times the

use of oxygen-free, high-purity copper anodes (OFHC copper) has been recommended, even for potassium cyanide baths (18, 19).

As a result of protracted trials it has been shown that in a high-efficiency copper bath based on potassium cyanide it is possible, by using OFHC anodes, to secure a good deposit $12\frac{1}{2}$ microns thick without any noticeable rough patches; whereas the normal electrolytic copper anodes throw off troublesome particles which reach the cathode and become embedded in the electroplated surface.⁽²⁰⁾

The content of free cyanide largely determines the degree of brightness. The condition of the bath is best tested by means of the Hull Cell.⁽²¹⁾ Tests of the quality of the cathode plates produced by the Hull Cell are a useful indication of the purity of the bath.

Practical experience indicates that chromium and zinc contamination give most trouble in a copper bath. Hexavalent chromium in particular adversely affects the uniformity of the copper deposit. Carefully controlled addition of sodium thiosulphate, which reduces the chromium to the trivalent form, has been shown to be efficacious in such cases.⁽²²⁾ In the bright copper bath as used with the addition of organic brightening media, the limit of tolerance for zinc contamination is about 1 gm. per litre. Higher contents of zinc result in brass-coloured deposits, particularly at high current densities. By adding sodium sulphide to the bath the zinc can be precipitated, but this operation is best carried out in a spare tank, which can also be used for other regenerating operations, such as treatment of copper or nickel baths with activated carbon. Filtering back the electrolyte into the working tank must be done with great care, as the fine zinc sulphide particles, if allowed to get through, can also cause roughness in the coating.

In the course of time the content of carbonate, at the rather high working temperature of the copper bath, rises at the expense of the hydroxide content, due to CO_2 absorption. By treating the bath with lime solution in the spare tank, calcium carbonate is precipitated and at the same time the degree of alkalinity is raised, and with it the conductivity.

The problem of filtration has long been neglected in the electroplating industry. Modern high-efficiency baths, however, require a periodic, or better still a continuous, filtration of the electrolytes; experience has shown that the best results are given by continuous filtration. An efficient filtering system, however, must have ample filter area (about 1 sq. m. per 1,000 litres) and adequate rate of filter pump delivery (about 2-3 times the bath content per hour). If the filters are of insufficient size, it is useless to attempt continuous filtration, as in such cases the bottom deposits are merely stirred up and cannot be got rid of fast

enough owing to insufficient circulation. The strongly alkaline copper bath also has the unpleasant property of causing the filter cloths to swell up, resulting in a rapid fall in filtering rate and a rise in pressure due to the increased resistance through the filter press. This increased pressure in turn results in undue strain on the filter cloth and possible leakage at the glands.

A difficult problem is to avoid macro-structure reliefs on the surface of the castings being reproduced on the electrodeposited copper surface. The surface of zinc die castings can, under certain circumstances, show a marked grain structure, particularly if allowed to remain too long in the etching bath, and it is well known that this underlying structure can reappear on the surface of the electrodeposit, particularly where the deposited metal has a fundamentally different structure from the basis metal. This reproduction of the structure of the basis metal is actually an indication of complete adherence of the deposit, and should be welcomed if it did not have a bad effect on the working of the brightening bath. It has in fact been found that these replicas of the structure of the casting cannot be altogether suppressed, even by a bright nickel deposit of 10-15 microns. This is a problem which is not easy to solve. Periodic current reversal has been tried to secure a smooth copper deposit, but the real solution seems to lie further back in control of the foundry technique (methods of gating, control of die temperature and casting conditions) with a view to securing a more even macro-structure in the casting.

These difficulties in electroplating zinc die castings might well be kept in mind by the designer in deciding the shape of the article. By suitable layout of the gating system it is possible to avoid streams of metal at different temperatures converging and overlapping in the die, resulting in varying cooling conditions between the gate and the point of solidification, this probably being the main cause of structural irregularities. It is seldom possible by subsequent heat treatment of the castings to improve the fundamental structure.⁽²³⁾ Thin-walled castings, on account of their liability to warping and blister formation, are in any case unsuited to heat treatment.

To improve the adhesion of the initial electrodeposit on zinc alloys, the use of brass in place of copper is sometimes recommended. The electrodeposition of brass of constant composition is, however, much more difficult than that of bright copper, while brass can only be deposited in a bright form in thin layers.

There is still a wide field for research in the formation of bright copper deposits. A really satisfactory bath for bright copper plating, without current reversal, using a potassium cyanide type of bath and with a constant degree of brightness, is

still a lot
baths ha
this pro
cyanide
and po
weakly a

After
which t
after fil
evapora
subjecte
pickled
acid, fo
before
to the
not giv
the alk
adhesio
experie

The
basic c
300 gm
37 gm.
60°-65
2-8 an
adjuste
thickne
time
micron
rough
for pa

The
a peri
the ca
there
the ac

Th
"pitti
adequ

Fig. 3.



still a long way off. Recently acid bright copper baths have been proposed for zinc castings, but in this process they must still be given a potassium cyanide copper strike. In addition to the sulphate and potassium cyanide copper baths, there are also weakly alkaline baths (pH 8-10) in limited use.

After rinsing in the drag-out recovery tank, in which the contaminated water is recovered and, after filtration, used as make-up water to replenish evaporation losses in the copper bath, the parts are subjected to further cold water rinsing and finally pickled in a 5 per cent. by vol. solution of sulphuric acid, followed by further rinsing in tap water before going to the bright nickel bath. Contrary to the views of some authors (²⁴, ²⁵) the parts are not given a further degreasing operation to remove the alkaline film, and no difficulty in obtaining adhesion of the nickel to the copper has been experienced.

The organic bright nickel bath is of the same basic composition as the Watts bath and contains 300 gm. $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$; 48 gm. $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ and 37 gm. H_3BO_3 per litre. Working temperature is $60^\circ\text{--}65^\circ\text{C}$ and the pH is maintained between 2.8 and 3.6. The average current density is adjusted to 5 amp. per sq. dm., which gives a mean thickness of deposit of 10 micron, with an immersion time of 10 minutes. The combination of $7\frac{1}{2}$ microns copper and 10 microns nickel corresponds roughly to A.S.T.M. B.142, type K.Z., suitable for parts subject to normal usage.

The maintenance of an even deposit demands a periodic checking of the bath composition. As the cathodic current efficiency is below 100 per cent. there is a loss of acid which must be made good by the addition of H_2SO_4 .

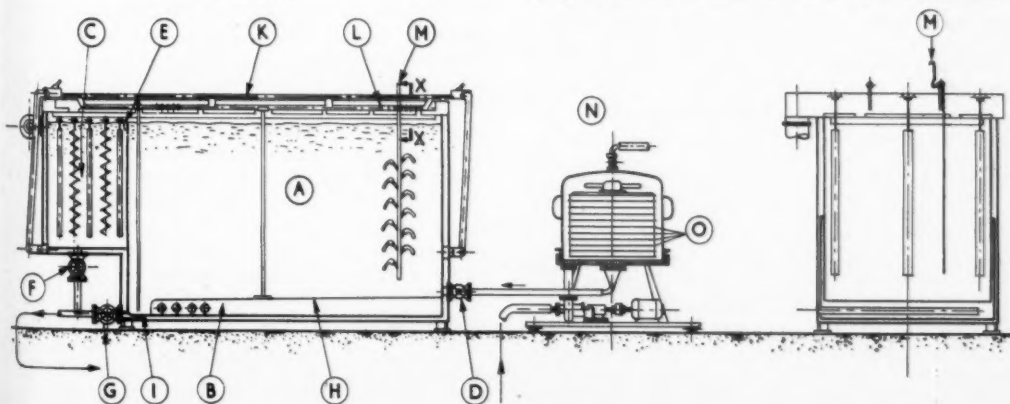
The hydrogen evolved at the cathode leads to "pitting" of the surface of the casting unless an adequate content of wetting agent is maintained.

Everybody engaged in the continuous production of nickel-plated zinc die castings has to grapple with the problem of bath contamination by both organic and inorganic impurities. Organic compounds have a bad effect on the brightness of the nickel deposit and often lead to brittleness. In the case of nickel-plated zinc die castings, this is generally not of paramount importance, as such castings are not in general subjected to strong alternating elastic deformation.

Organic contamination comes partly from the decomposition of the brightening addition agents and can in most cases be eliminated by means of activated carbon. But equal attention must be paid to inorganic impurities, though the problem varies from plant to plant—in the nickel plating of zinc castings most trouble arises from contamination by zinc and calcium.

The influence on the nickel deposit of contamination of the bath by zinc salts varies with the type of bath. The author's organic bath worked quite well at first, but in course of time there was a continuous contamination by zinc salts due to scratches caused by impact with the racks when loading and unloading, thereby exposing the underlying zinc. The previous tank design, lined with rubber and direct heated with horizontal heating elements at the bottom of the tank, made the recovery of "lost" castings (slipped from their moorings) difficult. The acid nickel bath then results in fairly rapid solution of zinc, the result being matt and brown-coloured deposits (when viewed at right angle to the surfaces, the colour was brownish, but when viewed at a glancing angle the colour was dull grey), particularly in the areas of low current density (< 1 amp. per sq. dm.). This phenomenon can be somewhat reduced by the addition of more brightening agent; treatment with activated carbon, if anything, makes matters worse, as the break-down products of the brightening agent, which are then absorbed by the activated

Fig. 3.—Diagram of electroplating installation for aluminium die castings.



carbon, partly compensate for the harmful influence of zinc. Treatment of the nickel bath with a suspension of nickel carbonate does not appear to be the most efficient or economic method for the removal of zinc contamination. It has been found that zinc is troublesome in concentrations even below 0.1 g. per litre, so that only the electrolytic selective purification method, using low current densities, can give satisfactory results. Fig. 3 gives the layout of the installation (supplied by R. Martin A.G., Basle, agents for the Dutch firm of Metallic Industry), which has been found to meet all the requirements of the plating industry.

The tank A, lined with hard rubber and having an indirect heating element B, contains a built-in compartment C for the selective electrolytic purification. From the filter unit N the clear bath liquid reaches the tank *via* the valve D. Under normal working conditions the solution flows *via* the overflow E into the built-in selective purification compartment, which has a separate rectifier and contains three nickel anodes and three corrugated sheet cathodes, on which the metallic contaminants, mainly copper and zinc, are deposited. The current density on the cathode sheets averages 0.5 amp. per sq. dm. The bath liquid leaves the plant *via* the valve F and goes to the filter press. The valve G is normally kept closed and is only used for the rapid removal of any bottom deposit of sludge in the tank, as and when required. If necessary, by closing F and opening G, the bottom deposits can be drawn off the sloping bottom without interfering with the operation of the plant. The practical man will welcome the installation of the "lost property office" I. By means of a rake any articles that have fallen off the racks into the bath can be recovered by being pushed down the sloping bottom of the tank to the recovery device at the end, which consists of a perforated ladle attached to a vertical rod, which enables these lost castings to be lifted out. This device reduces contamination of the bath to the minimum. An eccentric drive moves the suspension bar K at a speed of about $7\frac{1}{2}$ m. per min. A high speed of movement favours the rapid renewal of the cathode film and is advantageous from the electrochemical point of view. The friction of the fluid however, exerts a strong braking action on the racks holding the castings, particularly in the lower parts, necessitating firm fixing arrangements. The usual method consists of screw clamps, or attachment by guide rods L. The rack M is clamped to the suspension bar K and held in position between two of the guide rods. The filtering unit N is fitted with 11 filter cloths, made of acid-resistant material (total filter area 1.5 sq. m.) and has an initial filtering capacity of 4,500 litres per hour, and must be cleaned out every 4-6 weeks.

The use of hard water to make up evaporation

losses in the nickel bath is not recommended, as the continuous build-up of calcium salts results in the precipitation of CaSO_4 , which may cause roughness in the nickel deposit, although this can be largely reduced by proper filtering. However, the use of softened water, which can be produced in a modern synthetic resin ion-exchange plant, is much to be preferred.

To sum up, the following are some of the most desirable properties of the bath for use in the nickel plating of zinc die castings:—

1. Simple composition
2. Ability to work with high current densities.
3. Efficient and stable brightening additives.
4. Ability to produce bright deposits over a wide range of current densities.
5. Good adhesion of the nickel to the copper.
6. Insusceptibility to inorganic (Zn, Cu) or organic contamination.
7. Levelling characteristics*.
8. No tendency to passivation (in chromium plating).

The equipment for the bright nickel plating of zinc die castings should comply with the following requirements:—

1. Suitable tank lining (e.g., hard rubber).
2. Indirect heating, thereby avoiding stray currents.
3. Ample size of all containers, which enables the bath to be more easily maintained in chemical equilibrium.
4. Ample movement of suspended castings.
5. Continuous high-efficiency filtration.
6. Arrangements for selective purification.

In addition to the sulphate baths with additions of organic brightening media, bright nickel-plating baths containing strong chloride and cobalt additions are also in common use for zinc castings. Slow-working baths for the direct nickel plating of zinc castings have now more or less disappeared from the market, but trials are under way employing current reversal.

The nickel plating of zinc die castings sets many problems for the plater, and much attention has been devoted, *inter alia*, to the problem of the adhesion of the intermediate copper layer to the basis metal. For instance, does a copper deposit adhere more firmly to a mechanically roughened surface than to a highly polished one?

One would expect, on the analogy of experience with paint films, that a sand-blasted zinc casting would form an excellent anchorage. The question whether a rough or smooth surface gives the best results finds no conclusive answer in the literature⁽²⁶⁾. There is however, a consensus of opinion that maximum adhesion results when the covering

* This property is not always desired. To obtain certain decorative finishes, castings are sometimes pretreated (pattern marking), and such parts are required to retain the underlying pattern after bright plating.

metal combines with the basis metal or forms an alloy layer, or when the macrostructure of the basis metal is "adopted" by the covering metal. The author's experience is that the best adhesion is secured on flawless polished metal. In fact adhesion is found to be better on surfaces that have not been mechanically roughened than on those that have. The low micro throwing power (penetrating power) of the potassium cyanide copper bath is not conducive to good adhesion on rough surfaces (^{27, 28}).

The correct design and foundry technique for castings destined for subsequent electroplating are still the subject of various papers and discussion (²⁹). A foundry which has its own electroplating department is in the happy position of being able to secure close co-operation between the designer and electroplater, and is in the best position to turn out castings to give the best results in the finished article. It is most important that the designers of pressure die castings to be subsequently electroplated should keep certain principles firmly in mind:—

1. Sharp edges in general result in an increase in thickness of electrodeposit.
2. In sharp corners no metal is in theory deposited; at the best the layer is very thin.
3. Depressions are not easy to cover with a uniform deposit. The ratio of width to depth should be as large as possible.
4. Protruding parts will be covered with a thicker coating, at the expense of the areas furthest away from the anode.
5. Flat surfaces which are not broken up by ornamentation should be given a slight curvature.

Fig. 4 shows the variations in thickness of deposit that can occur on copper and nickel plated articles, from which it will be seen that the copper deposit is much more uniform than the nickel.

There is an increasing tendency in electroplating to demand minimum thicknesses of deposit that must be met in any part of the casting. The electroplater must decide, taking into account the throwing power of the bath and the shape of the casting, how best to meet these requirements without excessive consumption of materials. Much help can be secured in this direction by the use of auxiliary anodes, bi-polar electrodes and screens.

These various techniques play an important part in chromium plating. In general the chromium plating of nickel-plated castings gives less trouble from the physico-chemical point of view (pre-treatment, bath composition and current density) than in its practical application. The throwing power of the average chromium bath is decidedly bad (the SRHS bath is an exception) and the electroplater is often compelled to use auxiliary

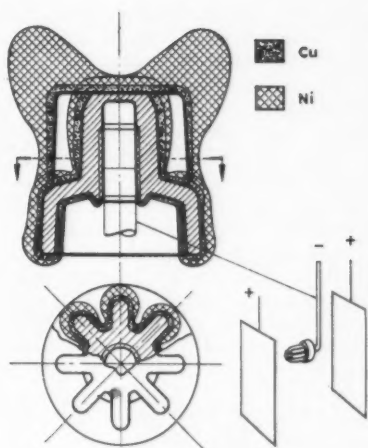


Fig. 4.—Diagram showing variations in thickness of deposit that can occur on copper- and nickel-plated articles.

anodes to secure an adequate deposit in corners and depressions.

The nickel-plated parts should be chromium plated at the latest after an interval of 5-10 minutes to avoid difficulties due to passivity of the nickel surface. Castings which may, contrary to usual experience, require buffing after the nickel plating, should be reactivated by cathodic degreasing and rinsing in a 5 per cent. sulphuric-acid bath before going to the chromium-plating bath.

The chromium bath contains 220-250 gm. chromic acid per litre. The ratio of H_2SO_4/CrO_3 should be 1.80-1.140. With a current density of 30-50 amp. per sq. dm. and a time of treatment of 10-20 sec. the deposit has a thickness of 0.1-0.2 micron. The high current density and short time of treatment was chosen because with longer times of treatment some "burning" can take place, particularly at the edges of the castings. The deposit of chromium which is used for purely decorative purposes contributes little to the corrosion resistance*. The chief value of this form of plating is its appearance, as it avoids the typical tarnishing of straight nickel plate.

The racks holding the chromium-plated articles go first to the drag-out recovery tank and then through the rinse tank proper. The considerable drag-out losses of chromic acid and the difficulties arising from the contamination of the rinse water make it worthwhile to study methods of regenerating the chromic acid by treating the rinse water in ion-exchange plants (³⁰).

* Corrosion tests of chromium plated parts are best carried out by the modified salt spray test, with the addition of acetic acid to the salt solution or by the "Corrodokote" test. The results of these accelerated corrosion tests are usually found to be more in line with long-term experience than is the case with other methods of testing corrosion resistance. (cf. W. L. Pinner. *Proc. A.E.S.* (1956), 43, p. 50.)

Drying of the chromium-plated articles is effected by dipping in hot water. Occasionally the dried parts exhibit spots caused by salt residues picked up in the hot water bath.

Hard water is not suitable for use in the hot rinse bath. Tests with water softened in synthetic resin ion-exchange plant have also not given entirely satisfactory results, as the sodium salts present in such softened water give rise to the same defects as hard water. De-salted or even distilled water also rapidly deteriorates through drag-out of salts on the racks. Other methods include centrifuging the parts in a stream of hot air or drying in perchlorethylene vapour. Some improvement can also be effected by reducing the surface tension of the hot rinse water.

Direct Chromium Plating of Zinc Pressure Die Castings

The direct chromium plating of zinc castings is carried out in some works in place of intermediate Cu and Ni plating. The well-known bath developed by Bornhauser, enables direct chromium plating to be done, using current densities of 20-100 amp per sq. dm.⁽³¹⁾ The dull grey deposit is relatively soft and can be polished without difficulty. In the U.S.A. a new chromium bath has been developed in which, as in the SRHS bath, the concentration of catalyst is automatically controlled. The chromium deposit can be polished and is, unlike the normal chromium plate, non-porous and shows a satisfactory resistance to corrosion⁽³²⁾.

The author's experience, is that the quality of a direct chromium plated zinc die casting is not in general equal to that of chromium over copper and nickel, at any rate as far as corrosion resistance is concerned. One must also remember that direct chromium plated articles must be subsequently polished, with all the well-known drawbacks (rubbing off at corners, and overall reduction of thickness).

Electroplating of Aluminium Pressure Die Castings

Aluminium pressure die castings can be electroplated in much the same way as zinc castings, provided they are pretreated according to the alloy used to secure adequate adhesion of the electrodeposit. In one method the thin natural film of oxide on the surface is reinforced by anodic oxidation, giving a porous film which acts as a good anchorage for the subsequent electrodeposit. In another much-used method, the cleaned castings are covered with a thin layer of zinc by being dipped in a zincate solution, and this zinc layer acts as foundation for the copper and nickel deposits. This is recommended by the A.S.T.M. as the most suitable method⁽³³⁾.

When nickel- and chromium-plated articles have been subjected to test, the results have not been very encouraging. For parts exposed to inclement atmospheric conditions, electroplating is not recommended, (this does not refer to the direct chromium plating of aluminium, about which opinions differ). Wherever local couples are set up, as for instance in pores, corrosion sets in and the aluminium goes into solution. This may easily lead to the formation of blisters and to the stripping of the electroplate.

It is possible that the purely chemical nickel plating of aluminium may give better results⁽³⁴⁾. Nickel deposits containing phosphorus made by chemical means are said to be hard and of uniform thickness. Chemical deposition can produce quite thin pore-free layers with a higher resistance to corrosion than those produced by electrolytic methods, and this technique merits serious attention.

Anodic Oxidation of Aluminium Pressure Die Castings

The anodic oxidation (anodizing) of suitable aluminium die castings can be carried out in all cases where the aim is to produce a corrosion-resistant film rather than a decorative one.

The problem of anodizing aluminium die castings with subsequent dyeing of the film to produce bright fast colours has not yet been fully solved, if importance is attached to uniformity of tone and a generally pleasing appearance.

Anodic oxidation also places definite limitations on the composition of the alloy to be used. High silicon, copper or iron contents are not favourable to the best results, which are given by alloys of the Al-Mg type (with or without the addition of Zn). New alloy types are however repeatedly being put forward as being particularly suitable for anodizing⁽³⁵⁾. The behaviour of castings in the three principal anodizing processes (based on sulphuric acid, oxalic acid and chromic acid baths) depends mainly upon the alloy used and the foundry technique. As regards alloy composition, it should also be mentioned that castings produced on hot chamber machines are not very suited to anodizing, as the high iron content is against the production of clear, bright films. On the other hand, the macrostructure of aluminium castings produced by the hot chamber process is in general more uniform than that of those produced by the cold chamber process, and this favours the formation of a uniform oxide film. The solidification conditions also influence the macrostructure and the resultant behaviour in anodizing. It is a well-known fact that alloys with a wide solidification range give clear anodic films.

(Continued in page 262)

Methods used in the Performance TESTING OF PAINT

by
W. V. MOORE, B.A. *

2. ADHESION

HAVING obtained a dried paint film, the next step is to test its physical properties. To do this a number of physical test methods have been devised, and are used extensively in the paint industry. It must be admitted that in some cases there is some doubt as to precisely which property is being measured and justification for their use must lie in their usefulness in actual practice. Also it must be borne in mind that the measurement of one property of a paint film may be affected by variation in another, *e.g.* the effect of adhesion when testing for hardness, so that the result of physical tests should be considered as a whole rather than individually. Further supplementary results supplied by visual observation made during the tests will then ensure that the best possible evaluation of paint properties is made.

Thus it will be seen that the physical testing methods used for paint films are far from perfect, only rarely giving a result which can be expressed as a simple number. The tests which are described here suffer from many defects but the results obtained can, when used properly, be of great use in evaluating paints.

Tests for Adhesion

The problem of measuring the adhesion of a paint film in terms of the force per unit area required to remove the paint from the substrate is one of very great difficulty. But there are two very simple methods by which a comparison between the adhesion of two or more paints can be obtained. These are the cross-cut adhesion test and a test using adhesive tape to pull the paint from the substrate.

In the cross-cut adhesion test a razor blade or sharp knife is used to make a series of eleven cuts through the film at a distance of $1/32$ of an inch apart. This is followed by a further eleven cuts at right-angles to the first so that one hundred squares of side $1/32$ of an inch are formed. All the cuts must completely penetrate the film. The amount of paint remaining intact after this treatment gives a measure of the adhesion. A rough quantitative measurement can be obtained by counting the squares, but the method is not of very great accuracy and it is probably better to grade paints as poor, fair, good, etc.

The loss of adhesion of the film in this method is due to the pressure of the blade on the film and its tearing action as it passes through it. A blunt or ragged blade will indicate poorer adhesion than a sharp fine blade. It is therefore essential that the same type of blade should be used for each test. The test is extremely useful for spotting the differences between the adhesion of a series of paints when all the paints are to be tested at the same time. But its use is much more limited when results are required for record purposes.

The second quick adhesion test is performed as follows: Two lines are cut at right-angles through the paint film with a sharp knife. A piece of adhesive tape is pressed firmly over the junction of the two lines and then jerked away as sharply as possible. The quantity of paint torn away by the tape gives a measure of the adhesion.

The success of this test depends upon the tape having a good adhesion to the paint and is limited by the fact that different tapes may have different adhesive properties. Estimation of results depends to quite a large extent upon the operator, so that

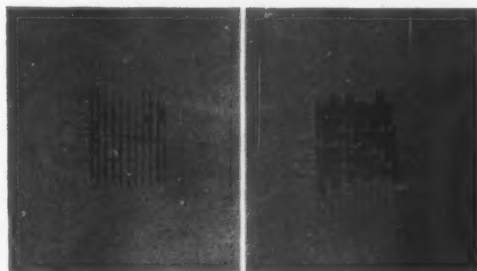


Fig. 1.—Examples of results obtained when testing paint for adhesion by the cross-cut test (above) and by the adhesive-tape test (below). In each case superior adhesion is exhibited by the sample on the left.



* Cellon Ltd.

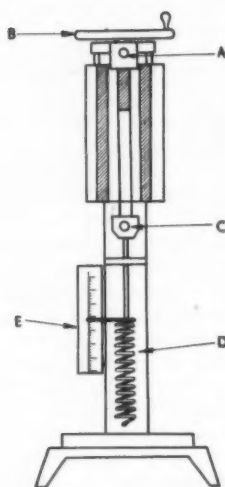


Fig. 2.—Diagrammatic illustration of the tensile-strength meter used for testing paint adhesion by the Gardner method.

two operators might put the same paint into different categories. This obviously limits the possibility of comparing the results of two different people or even the results that the same person has obtained at different times. Nevertheless, the results can, as in the previous case, be used to give a guide to the adhesive properties of different paints if the limitations of the method are fully realized.

Fig. 1 shows panels which have been tested for adhesion by these methods.

A method of obtaining a quantitative measure of the adhesion is the Gardner Adhesion Method which employs a tensile-strength meter and especially prepared panels.

The paint is applied to a panel of about 3 in. by 5 in. by the normal method. While the film is still tacky a piece of silk cloth is pressed upon it with a broad spatula so that it is firmly embedded. After the required drying period a series of cuts are made through the cloth and the paint at a distance apart of 1 cm. Thus the panel now carries a series of strips of paint 1 cm. in width and each carrying a piece of silk cloth. At this stage the paint is ready for testing in the tensile-strength meter.

A diagram of the tensile-strength meter with a panel in position is shown in Fig. 2. The panel is held by the clamp A and can be moved in a vertical direction by a screw operated by the handle B. The free end of one of the cloth strips is held by another clamp C. C is attached to a coil spring D whose lower end is fixed and which carries a pointer moving over the scale E. The scale is calibrated in terms of the force in grammes weight required to stretch the spring and hence any tension in the cloth strip can be measured.

To obtain a value for the adhesion the handle B is turned so that the panel is slowly and steadily

raised. This increases the tension in the cloth strip as measured by the extending spring until the limit of the adhesion of the paint film is reached. The paint then proceeds to peel off the panel as it is raised so that the spring is not extended further and the reading remains constant. This constant load as recorded on the instrument is the adhesive strength of the paint film.

Although as a general rule the reading remains constant after the paint has begun to peel, the panel should be raised until all the paint is removed in case any inconsistencies appear. Such inconsistencies, giving rise to variable readings, may be due to imperfectly prepared panels which have not been perfectly degreased or which contain corrosion pits. To obtain reliable results the test panels must always be thoroughly degreased before painting and any panels which show traces of corrosion must be rejected for these faults will cause a decrease in the apparent adhesion. Another cause of variable results is lack of cohesion in the paint itself. If the cohesive forces in the paint are less than or very nearly equal to the adhesive forces with respect to the substrate then the film may start to tear apart instead of peeling from the surface. Cases of cohesive failure can be detected by the small patches of paint which remain attached to the panel after the test has been applied.

The Gardner Adhesion Method can also be used to determine the adhesion of one paint to another or the cohesion of successive coats of the same paint. To do this the first coat is applied to an amalgamated tin panel and the silk cloth embedded as before. When the first coat is dry, the second coat is applied and the procedure repeated. Finally the complete system is stripped from the panel, a thing which can be done very easily since the amalgamated tin provides a liquid film between the panel and the paint. The paint film with its two embedded strips of fabric is cut into pieces 1 cm. in width and the fabric slightly separated at one end. One section is attached to the top clamp of the tensile-strength meter and the other to the bottom. The sections of cloth are pulled apart as in the previous case and the scale reading gives the adhesive force between the two coats of paint.

This method of measuring the adhesion of paint films has the advantage over the previous methods of giving results which do not depend upon the operator's assessment. This is especially useful when measuring the adhesion over a period of time. Using the cross-cut adhesion method it is difficult to get a reliable comparison of results unless all the measurements are made on the same day. This can be overcome by painting a series of panels at different times so that the adhesion measurements all fall due at the same time, but it is much simpler to use the tensile-strength machine and tear a strip from a panel at various intervals of time. The

(Continued in page 246)

A MODERN PLATING SHOP FOR PRECISION EQUIPMENT

A Brief Description of Recent Additions to Finishing Facilities at the Mitcheldean Works of RANK PRECISION INDUSTRIES Ltd.

IN 1941, after their factory at Shepherds Bush, London, was bombed, Rank Precision Industries Ltd. moved to premises, in the little village of Mitcheldean in Gloucestershire, which were formerly occupied by a brewery. Many extensions have been made to the works since 1941, culminating in the erection of a modern electroplating and polishing shop, heat-treatment shop and metallurgical laboratory. In the works a wide range of precision equipment, including ciné cameras and projectors, microfilm readers, still projectors, etc., is manufactured.

Because of the lack of skilled personnel in the area, the company found it necessary to introduce relatively complicated tooling and to give specialized training to individual personnel for one particular job or assembly operation. This procedure has been found to confer special advantages to the type of product manufactured. Cameras and projectors are made to designs of the Bell and Howell Company in the U.S.A., these being marketed in the U.K. under the name of G.B.—Bell and Howell, and all parts, whether of British or U.S.A. manufacture have to be interchangeable so that a customer anywhere in the world can be assured that a spare part will fit apparatus manufactured in both countries. Skilled instrument makers would tend to make all parts “fit” a particular piece of equip-

ment, so destroying the “interchangeable” nature of the part in question.

Because of the high accuracy required, extremely careful control of all materials used is maintained, and, in addition, inspection, both of individual components and completed equipment, is 100 per cent.

The modern paint shop in the works includes six spray booths and a gas-fired conveyORIZED oven. Die-castings, of which a large number is used in the company's products, are given a chemical etch treatment and are passed through an infra-red drying oven and straight into the paint shop.

The total floor area of the new plating and polishing shop, which has been installed by W. Canning and Co. Ltd., is 8,400 square feet, the plating shop itself having a floor area of 3000 sq. ft. The building itself, an outside view of which is shown in Fig. 1, consists of two storeys, the upper of which houses the polishing department (Fig. 2); the plating shop is on the ground floor (Figs. 3 and 4). In the design of the shop the emphasis has been on quality rather than quantity production, and because of the particular needs of the company's products, it was thought impracticable to incorporate any form of mechanized plating in view of the exceptionally varied number of components, the number of different plating methods required,

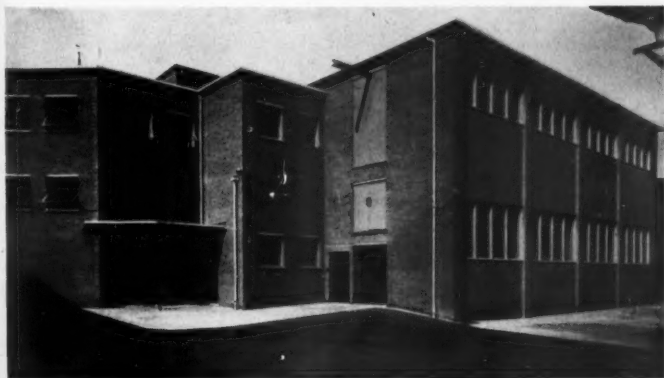
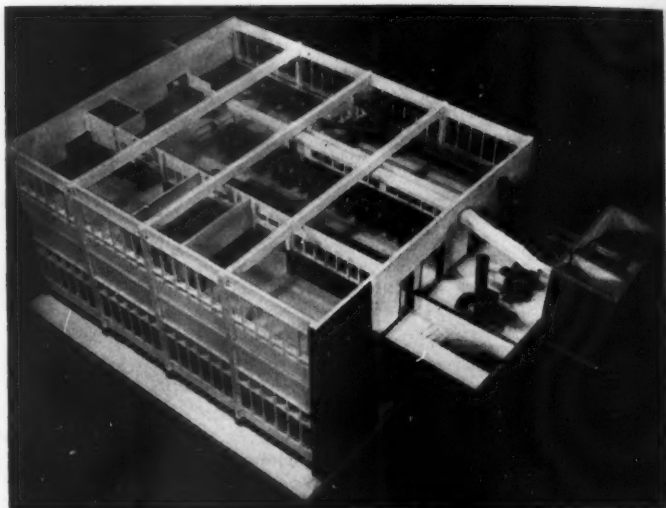


Fig. 1.—General outside view of plating/polishing shop at Rank Precision Industries Ltd.

Fig. 2.—This model of the new building (with the roof removed) shows the layout of the polishing department, ventilating and extract equipment.



and the comparatively small batch quantities.

The building layout is such that all expensive machinery, transformers, rectifiers and ventilating fans are in separate rooms isolated from dust and corrosive fumes. Transformers and rectifiers are on the first floor and in the majority of cases are positioned vertically above the plants they supply, so keeping low-tension, high-current leads as short as possible.

Between the first and the ground floor ceiling, lattice girders have been used which form a false ceiling space of about 4 ft. 6 in. in depth. This form of girder construction is such that no stanchions are required in the plating shop below.

Horizontal runs of ventilation and exhaust

ducting, air, gas, and water pipes, and electric feeds of all descriptions are housed in this false ceiling, which is so sealed that fumes from the plating shop cannot penetrate. As an extra precaution the space in the false ceiling is supplied with fresh air.

The above method of housing services was chosen not only because of its relative cheapness, but also because of the ease with which any required alterations to the various services can be made if required. At the points where pipes or electrical feeds leave the ceiling to descend vertically to the various tanks they feed, a change is made either to plastic or copper pipe, and to plastic-aluminium-covered cable. Thus all services to the plating shop

(Continued in facing page and in page 246)



Fig. 3.—General view of interior of plating shop.

Fig. 4

Fig. 5

Courtesy





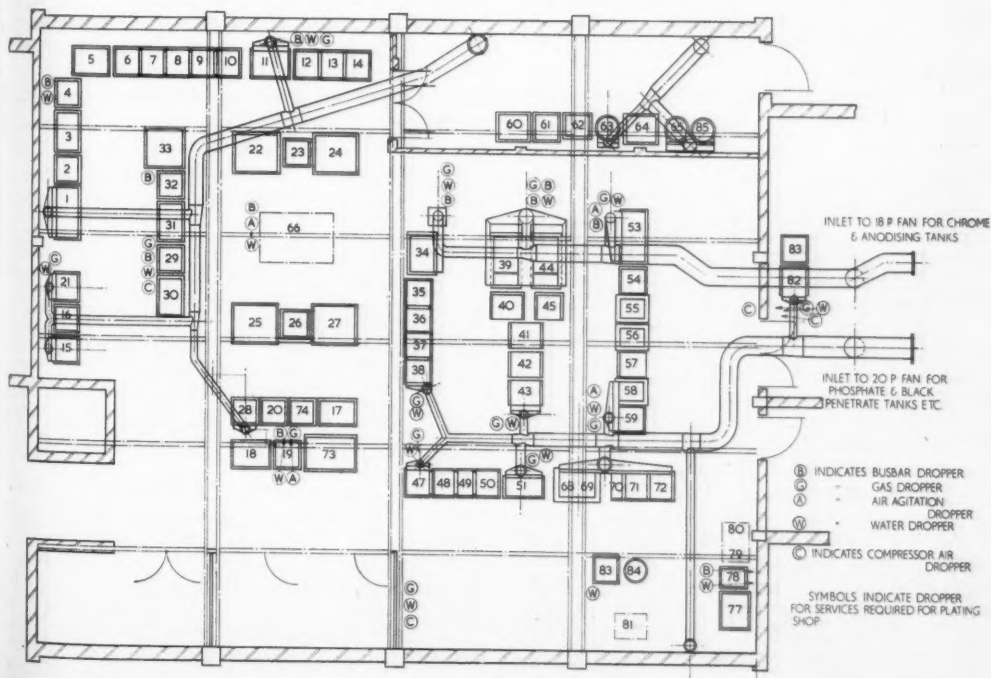
Fig. 4 (above).—View of hard-chrome plating unit.

LEGEND TO FIG. 2

1	Zonax Cleaner	44	Hard Chrome and Etch
2	Cold Water	45	Chrome Swill
3	Kleenax Cleaner	47	Zonax Cleaner
4	Cold Water	48	Cold Water
5	Kleenax Cleaner	49	De-Oxidene
6	Cold Water	50	Cold Water
7	Acid Dip	51	Phosphate
8	Cold Water	52	Degreaser (not shown)
9	Cyanide Dip	53	Sulphuric Anodic
10	Cold Water	54	Cold Water
11	Copperplating	55	Dye Tank
12	Cold Water	56	Dye Tank
13	Acid Dip	57	Cold Water
14	Cold Water	58	Nickel Acetate Seal
15	Ferric Chloride	59	Hot Swill
16	Cold Water	60	Laybore Nickel Strip
17	Dull Nickel Plating	61	Cold Water
18	Cadmium Plating	62	Calistic Chrome Strip
19	Cold Water	63	Hot Pickle (Jowl)
20	Kadip	64	Cold Water
21	Hot Water	65	Nitric Acid Dip (Jowl)
22	Bright Nickel Plating	66	Nickel Storage
23	Cold Water	67	Centrifugal Drier (not shown)
24	Bright Nickel Plating	68 & 69	Black Penetrate
25	Bright Nickel Plating	70	Dragout
26	Cold Water	71	Cold Water
27	Bright Nickel Plating	72	Hot Water
28	Hot Water	73	Bright Zinc Plating
29	Cold Water	74	Cold Water
30	Copper Sulphate	75	Oil Dip (not shown)
31	Black Nickel Plating	76	Ferromede (not shown)
32	Cold Water	77	Midget Barrel and Tank
33	Black Nickel Plating	78	Cold Water
34	Bright Chrome Plating	79	Minor Barrel
35	Cold Water	80	Minor Barrel
36	Cold Water	81	Major Barrel
37	Cold Water	82	Hot Water (Tumbling Shop)
38	Hot Water	83	Cold Swill
39	Hard Chrome and Etch	84	Chrome Dip
40	Chrome Swill	85	Nitric Acid
41	Cold Water		
42	Cold Water		
43	Hot Swill		

Fig. 5 (below).—Diagram of layout of plating shop.

Courtesy of W. Canning and Co. Ltd.



New Plating Shop

(Continued from page 245)

have good corrosion resistance which is further enhanced, in the case of copper pipes, by epoxy-based paint.

The interior walls of the plating shop are tiled and the usual acid-resisting floor is fitted. All exposed metal parts are also protected with epoxy-resin paint.

For transport of work between floors a lift with solid doors has been used in preference to a conveyor system, in order to prevent fumes from the plating shop reaching the polishing shop on the floor above.

The layout of the plating shop (Fig. 5) is on a circular-flow basis so that the shortest time-cycle work has the shortest route and *vice-versa*. Cleaning processes have been given special attention and a water-softening plant has been provided to supply all preplating tanks.

For nickel plating, duplicated small tanks have been installed so that balanced loads of identical components will ensure even and precise thicknesses of plating.

Filtration is effected by a pump and a large storage tank, while Permutit demineralizers supply the water used for the making-up of plating solutions.

All effluent leaves the building by means of a separate drain to the purification plant through which it passes before discharge to the public drainage system.

In the plating shop fresh air, which can be heated if required, is supplied by a ventilating system

through regulated ceiling panels. Four separate exhaust systems extract fumes and steam giving approximately 22 changes of air per hour. This air conditioning plus the removal of all noisy machines to special rooms has provided pleasant working conditions.

In the polishing shop the necessary dust extraction plant forces good ventilation, but to ensure warmth and to effect economy the dust-extraction unit has been built into the building and is constructed to allow the air to be pumped back into the polishing shop, after double filtration. Accommodation has been included to permit balanced mixing of return air and fresh air as is found necessary.

On the first floor, wiring up and degreasing is also carried out.

Since the new plating and polishing shops have been in operation the following increases in capacity have been recorded:

Nickel plating...	...	...	50 per cent.
Black nickel ...	...	...	50 " "
Steel blacking...	...	...	50 " "
Tumbling ...	...	...	50 " "
Hard chrome ...	...	...	100 " "

Anodizing and zinc plating have been added to the range of finishes previously carried out.

Although barrel plating is used only to a limited extent this process is used for black nickel. In addition, some case-hardened mild-steel components are barrel burnished as a finish.

Analytical control is operated on a rota system, and quality is controlled on a sampling basis, records being kept on visible charts. These are analyzed on completion and action taken on the results where necessary.

Testing of Paint

(Continued from page 242)

disadvantage of the method lies in the tedious business of embedding a piece of silk in the wet paint. Also, of course, it cannot be used for paints whose normal film thickness is too small for this to be done, while the use of increasingly high stoving temperatures renders the use of cloth impracticable. There is also some doubt as to whether the results obtained are an actual measure of the adhesive force. For the force of adhesion presumably acts normally to the interface and is not necessarily the same as that required to peel the surfaces apart.

Some instruments have been designed to measure normal adhesive forces. One method uses an ordinary metal tensile-strength specimen: The specimen is cut in half and the paint applied to the exposed surface on one half. When the paint is fully dry the second half of the specimen is stuck on top and the pieces are pulled apart in a tensile-

strength machine, the force required to do this being a measure of the adhesive strength of the paint.

One of the chief difficulties involved in using this method is to find a material which will satisfactorily stick the second half of the specimen on to the first. Such a material must have better adhesion to the metal and to the paint than the paint has to the metal and also it must not attack the paint film while drying. Cold setting glues, which will do this for some paints, are now available but the method is still difficult to perform and has only been used to a very limited extent.

Thus measurement of the adhesion of paint films becomes very difficult if quantitative results are required. The very much simpler methods such as the cross cut adhesion method give results which are definitely qualitative but which are ample to give a differentiation between paints of various types. This, rather than a definite figure, is generally all that is required for everyday use.

THE INSTITUTE OF METAL FINISHING

1957 ANNUAL CONFERENCE IN BRIGHTON

Report of Technical Sessions

(Concluded from page 216, May, 1957)

Abstract No. 6

A Contribution to Knowledge of Cathode Polarization Phenomena of Nickel

By R. Piontelli and G. Serravalle*

IN the introduction to this paper the authors state that present knowledge regarding the cathodic polarization behaviour of nickel is far from satisfactory, and this is true not only from the theoretical point of view but also from the phenomenological one, existing data being concerned only with sulphate and chloride solutions in particular conditions.

The paper summarizes some experimental results obtained in the course of systematic investigations on the anodic and cathodic behaviour of metals. The work upon nickel has been carried out in a wide range of conditions and with uncommon solutions such as sulphamate, perchlorate and fluoborate, practical interest in which is increasing. In view of the fundamental importance of overvoltage in practical plating these results have interest from the technical point of view.

The experiments were carried out in special cells designed by the authors and the so-called "direct method" has been used in which the electrode potential is measured or recorded with respect to a suitable reference electrode before, during, and after the passage of current pulses whose form, intensity and duration may be adjusted over a wide range. A silver voltmeter in series with the measuring cell allowed the mean current efficiency in any series of measurements to be determined. The cathodes were of very pure nickel which was also used for the preparation of the solutions and of the soluble anodes. The solutions were made up of from chemically pure reagents using conductivity water. The influence of preliminary electrolysis and the effects of treatments for the elimination of organic substances were investigated. The pH of the solutions was measured electro-metrically using a glass electrode and all the solutions (to which reference is made) were buffered by means of boric acid.

In considering the experimental results as a whole it seems unlikely that explanations depending upon the structure of the metallic phase or on the surface condition of the cathode can provide a full explanation. Equally the view that the electrode behaviour of nickel is determined entirely by the properties of the dissolved nickel ions can hardly be accepted. The combined point of view long ago advanced by one of the present authors takes account of all the acceptable conclusions of the points of view of other investigations and it appears is at present the only suitable standpoint for a qualitative understanding of the electrode behaviour of nickel. According to this point of view account must be taken of:

- (a) bonding of the nickel ions, both in the lattice and in solution;
- (b) the direct role of the anions in the ionic transfer reaction;
- (c) the eventual passivation of the metal surface by adsorption.
- (d) the conditions of formation and the electrical and electrochemical properties of the finally deposited layers.

All the properties of nickel ions which are largely responsible also for the whole of the physical and chemical properties of nickel and its compounds, are clearly in agreement in making the activation energy of the transfer processes high.

The very important influence exerted by the anions (according to the experiments) agrees quite well with the general rules, established by the authors for the influence of anions on the electrode overvoltages of a large group of metals. Those anions which are most deformable under the influence of electrostatic fields, particularly chloride ions, are also the most efficient in activating ionic exchange at the metal/solution interface.

In the case of nickel the nature of the anion is very important, also in affecting the conditions of formation of basic colloidal compounds in the cathode layer and affecting also their properties and their acclusion in the deposits. This must be the case in view of the physical properties of the deposits although the authors consider that the influence they have on cathode overvoltages is indirect and not essential.

* Technological Institute of Milan

Abstract No. 7

The Change of Fatigue Limit on Chromium or Nickel Plating with particular reference to the Strength of the Steel Base

By C. Williams* and R. A. F. Hammond*

IN an earlier investigation the authors established that for a particular steel (EN.25), in two different conditions of heat treatment the fatigue limit after chromium plating was independent of the ultimate tensile strength of the steel over the range 60 to 80 tons per sq. in. although the percentage loss of fatigue strength was higher for the harder steel. It was also found that the fatigue strength of steel after chromium plating was determined (a) by the magnitude and sign of internal stress in the chromium deposit, and (b) by the intrinsic fatigue strength of the chromium deposit. From this investigation, also, it appeared that with relatively strong steels, fatigue failure is initiated in the chromium deposit and the fatigue limit of the plated component is limited by the intrinsic fatigue strength of the chromium. In this light, therefore, it seemed likely that the fatigue limit of low-strength materials might be increased by chromium plating and the present investigation was therefore initiated to test this point and to check the previous results by using steels of different composition and with a wider strength range.

For the tests, steels both plated with chromium (0.006 in.) and unplated were used and standard Wohler fatigue test-pieces were used. These were rough machined, ground to size, and the working area of the test-piece anodically polished. Determinations of internal stress in the deposits were also made at intervals. Similar test-pieces were used for the nickel-plating tests, the plating thicknesses used being 0.001 in. and 0.005 in. Tensile and hardness tests were also carried out.

The chromium-plated test pieces were fatigue tested in the "as plated" condition, *i.e.* without surface grinding. The maximum applied stress was calculated from the usual elastic beam formula, the values being calculated on the full diameter of the plated specimen.

For the nickel-plated specimens the majority of specimens were fatigue tested in the "as plated" and heat-treated condition. Some of the deposits, however, were "lapped" before testing by lightly polishing with fine emery paper.

The experiments showed that when steel is chromium plated there is a linear relationship between the percentage change in fatigue strength

and the fatigue limit of the steel. Arising from this it is possible, for unbaked deposits of known internal stress, to predict the percentage change in fatigue strength on chromium plating from a knowledge of the fatigue limit, ultimate tensile strength or diamond point hardness value of the steel irrespective of its composition, and a formula has been derived for this purpose.

With very soft steels the fatigue strength may be increased by chromium plating and there is evidence to suggest that failure is initiated in the steel at the interface. For conventional chromium with an internal stress of about 4 tons per sq. in. this condition applies for steels of 18 tons per sq. in. fatigue limit or less. With steels exceeding this strength the chromium fails first when the applied stress plus the internal stress reaches the inherent fatigue limit of the chromium, *i.e.* 20 to 22 tons per sq. in. Propagation of the fatigue crack in the chromium into the steel does not appear to occur until the stress concentration at the root of the crack approaches the fatigue limit of the substrate.

Although the greater complexity of nickel deposition has so far precluded similar clarification of the conditions governing the fatigue failure of nickel-plated steel, there is definite evidence to suggest that the same general considerations apply and that for certain types of nickel deposit the linear relationship between the percentage change of fatigue limit and the fatigue limit of the steel base holds.

As in the case of chromium, there appears to be a linear relationship between the internal stress in the nickel deposit and the percentage change in fatigue strength, and in contrast to "as plated" ("unbaked") chromium deposits, the percentage loss of fatigue strength increases with the thickness of some nickel deposits.

Discussion

Mr. H. FRY (British Non-Ferrous Metals Research Association, London) said that in the work described in their previous paper, the authors measured the stress in deposits 0.001 in. thick, whereas the thickness of the deposit on the fatigue-test specimens was 0.006 in. His own measurements of stress led him to think that the stress in 0.006-in. deposits might be much smaller than in those of 0.001 in., and this decrease in stress between 0.001 in. and 0.006 in. thickness might well exceed the scatter which the authors had observed to exist among the internal stresses in their deposits.

The authors pointed out in their previous paper that there was little difference in the fatigue limits of 0.001-in. and 0.006-in. thick deposits. Had they carried out any further confirmatory tests on this point? They also showed that, particularly for basis steels of high fatigue strength, the internal

* Armament Research and Development Establishment, Fort Halstead.

stress in the type of deposit which they had plated made little difference to the reduction of fatigue strength. It occurred to him in this connexion, however, that if the deposit was very thin and still uncracked, so that the internal stress was still very high, the reduction in fatigue strength might be very much greater than in the case of the 0.001-in. and 0.006-in. deposits which the authors had considered, and the effect, in fact, might be quite catastrophic. Perhaps they could think of some reason why it should not be. In any case, he wondered whether articles with thin deposits of chromium were ever used in conditions where they would be subject to fatigue stresses.

Fig. 2 in the paper gave the results of the survey of the literature which the authors carried out, and they quoted it as support for their own experimental results with regard to the straight-line relationship between the percentage reduction in the fatigue limit and the fatigue strength of the basis steel. How much confidence did the authors place in this as a confirmation of their own results, rather than as not actually contradicting them?

Mr. Fry then asked why the experimental points in Fig. 2 had such a large scatter. It was true that, as the authors pointed out, scatter in experimental points from 19 different sources was not surprising; but it should be borne in mind that all the results represented in Fig. 2 referred to conventional chromium-plating solution containing chromic acid and sulphuric acid only, and also that variations in internal stress had been found by the authors to be relatively unimportant in decreasing the fatigue limit of plated steels, particularly those with an intermediate to high fatigue strength. The scatter of the points in Fig. 2, for steels of high fatigue strength, was at least as great as that for steels of lower strength, and it was therefore unlikely that the scatter was accounted for by the internal stress.

Could it be that the fatigue limit of the chromium deposits varied depending on the conditions of deposition? This was a point of considerable interest to Mr. Fry. Another possible explanation for the spread of the experimental points was that there was some difference in the method of fatigue testing.

CONFERENCE CAMEOS

(Top) Two overseas visitors to the Conference, Mons. P. Morisset, director of the Centre d'Information du Chrome Dur, France, with Mons. R. Chevalier, Chef de Section, Traitements de Surfaces, S.N.E.C.M.A., France.

(Centre) Mr. L. W. Stubbs, general sales manager, Mr. W. E. K. Piercy, director, and Mr. W. K. Bates, manager, metal-finishing department, of Albright and Wilson Ltd., congratulate Dr. G. E. Gardam on his award of the I.M.F. Gold Medal.

(Bottom) Mr. S. A. Watson, investigator, and Dr. J. Edwards, head of electrodeposition section of the British Non-Ferrous Metals Research Association with Mr. W. K. Bates, Albright and Wilson Ltd., and Dr. D. Layton, technical manager of the Iomic Plating Co. Ltd.



In the discussion of the results the authors derived a number of equations relating the percentage change in fatigue strength to the fatigue limit of the basis metal. In equation (5), for instance, the physical dimensions of the left-hand side were zero, and the terms on the right-hand side also had to be pure numbers. This implied that the dimensions of the factors 2 and 3 must be those for reciprocal stress, *i.e.*, area divided by forces. Could the authors give a physical interpretation of these factors which represented the slope of their straight line? Were there some material constants, and, if so, did they depend on the state of the material, as did other material constants? In this case, of course, the state of the material would depend on the conditions of deposition, and, if that was so, it might be that the slope of the line which was represented by the material constant relating the percentage change in the fatigue strength with the fatigue strength of the basis metal would also, therefore, depend on the plating conditions. Had any tests been made on this point? If the slope in equation (5) was dependent on the plating conditions, then the usefulness of the equation for calculating design factors would be somewhat reduced.

In this connexion also, he wondered, whether any tests similar to those described in the paper had been made with non-ferrous alloys, and whether similar relations had been found.

The explanation which the authors gave for the exact value of fatigue strengths was extremely interesting, even though, if he had understood the implications of their previous paper correctly, the idea of the notch effect had to some extent been abandoned. If the importance of this effect was now again admitted, did not it follow that the effect of the stress concentration at the base of the cracks which occurred naturally in most chromium deposits should also be taken into account? This led back to the point that the intrinsic fatigue strength of chromium deposits might depend on the conditions of deposition.

It would have been useful to have seen a photomicrograph through a section of a not-completely-failed fatigue specimen which showed a fatigue crack in the chromium deposit, to illustrate Fig. 10, 2 and 3, which suggested the mechanism to explain the particular values of the fatigue strength found by the authors.

There was no doubt in his mind that by their experimental work, as well as by their formulation of the new and fairly detailed mechanism of the cause of failure in plated components, the authors had made an appreciable step forward towards the elucidation of the effect of plating on the fatigue strength of steels.

Mr. J. W. OSWALD (Fescol Ltd., London) congratulated the authors on their paper, which was

of immense practical importance, because so much hard chromium-plated material was being incorporated in modern aircraft, and many of these components were stressed to the limit before chromium is put on them. It was certainly of great importance to know beforehand exactly what effect the chromium deposit was going to have on the component in question.

He noticed that the authors seemed to ascribe the whole of the effect to the chromium deposit itself. He felt sure that they could not have ignored the effect of hydrogen adsorption, and, therefore, how would they incorporate that effect in their equations? It was well known that hydrogen on its own had an effect in reducing the fatigue limit of steel, but it might be that that effect was simply a constant which had to be incorporated in the equation and therefore did not substantially alter the equation itself, but only made a shift in the curve.

Effect of Grinding

Many components used in engineering were necessarily finished by grinding. The authors mentioned, when dealing with nickel, that lapping the surface increased the fatigue limit. He wondered whether finishing the chromium-deposit test either by the normal commercial method of grinding or by lapping to a finish would have any effect in altering the loss in fatigue strength? Were the untreated specimens electropolished before testing?

Mr. Hammond, in presenting the paper, mentioned that tensile strength and hardness went hand in hand. For the 0.5 per cent. carbon steel quenched and tempered at 200° C the figure for D.P. hardness given in Table I was 620, and the tensile strength was given as 66 tons per sq. in. He thought that the figure of 620 was more likely to be 320, but there might be some explanation of that.

Dr. T. P. HOAR (University of Cambridge) said that with regard to Figs. 1 and 2, the authors showed an extremely interesting correlation between their own results and previous results. Had the previous results been treated statistically? He knew that it was not a normal distribution but there was a large number of points, and it would be interesting to see a least squares line drawn through those points as it seemed as though such a line would coincide accurately with the line of Fig. 1 and show the correlation between present and previous results in an even more striking manner.

In their empirical equations the authors obviously had something which was going to be of great use to designers. All that was required was to take the empirical equation, insert the appropriate values, which were known, and obtain the answers required in terms of reduction of fatigue limit.

He hoped, however, that these equations would not be found in specifications in two years time! When a designer obtained a simple equation which he could use for practical purposes, he was inclined to attach a much more fundamental value to it than it really had. Dr. Hoar was sure that the authors would not want that to happen with these equations, and thought that they would be extremely valuable, provided that those who used them kept their wits about them.

Mr. P. MORISSET (Centre d'Information du Chrome Dur, France) said that he thought that the research work of the authors was of great importance in the problem of the fatigue limit of chromium-plated steels. However, the pieces had been tested "as plated", that is to say, without surface grinding. When grinding was done after plating, and especially when this grinding was severe, local heating might occur, and this, he imagined, would disturb the initial internal stress of the deposit. Had the authors any idea of the importance of this influence of grinding on the internal stress of the deposit? Did they think that their remarkable conclusions were also valid when normal surface grinding was done after chromium plating?

Mr. K. J. WHITE (Dentsply Ltd., Brighton) invited the authors to comment on the possibility of a direct relationship between their work with steel as the basis metal and other basis metals. Had any work been carried out in this direction?

Dr. D. N. LAYTON (Ionic Plating Co. Ltd.) said everybody who did large industrial plating periodically ran into trouble on hard, brittle steels after plating due to cracks arising if the steel had not been properly stress-relieved before plating. There was no doubt that in the absence of a stress-relieving treatment before plating hydrogen had a much more deleterious effect on the final product than it would otherwise have, and incipient cracks which were not troublesome before plating might become so after plating. If the authors continued with this work, perhaps they might consider the use of magnetic crack-detection methods on their steel test-piece before plating and after plating, especially if they were dealing with hard steel, where this type of trouble most commonly occurred.

Mr. E. A. OLLARD (Atlas Plating Works Ltd.) said that with regard to Dr. Layton's point, he believed that crack detectors had been used and had demonstrated cracks forming in the steel under a nickel deposit just before fatigue failure on a fatigue test-piece, when the cracks did not show through to the surface.

Authors' Reply

Mr. C. WILLIAMS said that internal stress measurements in fatigue tests were done, as before, with 0.001 in. of chromium. In the very early

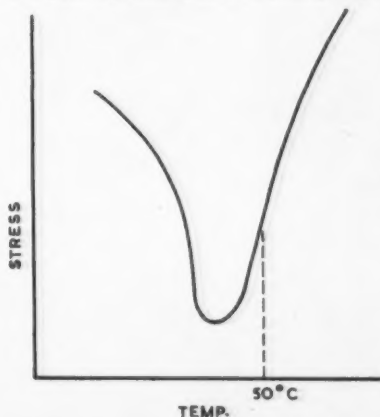
tests it was found that the stress with a deposit of 0.006 in. was of much the same order, but subsequent to that work an American paper with proprietary chromiums had shown that the stress falls with thickness of deposit. He had assumed that if the value at 0.001 in. was high, the value at 0.006 in. would also be high.

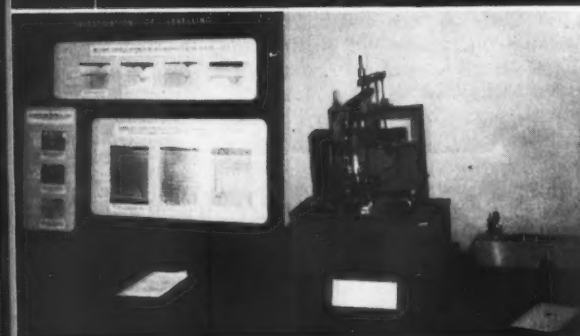
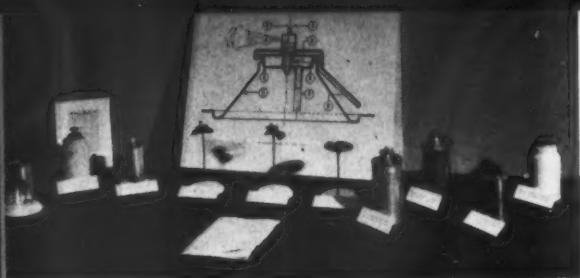
The next point was the effect of thickness of chromium on fatigue strength, a point on which he had some unpublished data which was somewhat surprising, and about which he was not very happy at the moment. If the fatigue limit after chromium plating was plotted against the thickness of deposit, up to 0.001 in. the fatigue limit fell, in spite of the fact that at low thicknesses there were high values of internal stress. This was probably associated with the fact that thin deposits of chromium were relatively sound.

As regards confidence in the values quoted in Fig. 2, the authors thought that there was so much scatter that it was not worth putting in a line of least squares. If Fig. 1 was put on Fig. 2, the curve fell in the middle of the band. With regard to the likely reasons for the scatter in Fig. 2, the method of calculation might come into this, because many workers seemed to use the diameter of the unplated steel for calculating their stress values, while others had used the full diameter after chromium plating. It was possible that internal stress might play quite an important part, in spite of equation (5), in which it played a comparatively small role, though it was, he thought, significant. In the authors' earlier paper there was a figure in which was plotted the internal stress of the chromium deposit against the plating temperature producing a curve of the type shown below.

A difference in plating temperature of 2° C made a large change in internal stress. In that con-

Type of curve produced when the internal stress of a chromium deposit is plotted against the plating temperature.





nexion, he thought that many of the published data were with chromium deposited at 55° C and not the 50° C used by the authors.

No work had been done in recent years on chromium plating on non-ferrous materials. If he were to hazard a guess, he would say that, since the work was concerned mainly with the strength of the material itself and not with structure, probably the results would be of the same order or type.

The next question concerned stress concentration or cracks in the chromium. In a deposit showing in section a large number of small plating cracks, he imagined that the stress concentration at the root of any one of them would be comparatively small; but if the plating were done at a higher temperature and there were a few large cracks, the stress concentration would be comparatively high. He regretted that it had not been possible to produce some sections of fatigue test-pieces with chromium cracked at various stages. On the question of cracks, perhaps he could take Fig. 10 a little further. In Fig. 10 the authors had shown the stress concentration in the steel after the chromium had cracked. If a compressive stress was put in the steel before plating, this stress concentration would be largely eliminated, and in those conditions the cracks in the chromium were not particularly important.

Mr. Oswald raised the question of the effect of hydrogen on fatigue strength. As he understood it, hydrogen had a negligible effect on the properties of a material below its elastic limit, and in a paper published a year or so ago it was shown that with a high-tensile steel of about 100 tons per sq. in., hydrogen had a negligible effect on the fatigue limit.

No tests had been carried out on the effect of grinding but Mr. Logan had carried out some tests and had shown that grinding had a negligible effect on the fatigue strength—if it was done properly. The only test which he could add had been done fairly recently on two test-pieces. If here was a compressive stress in the steel surface

TECHNICAL EXHIBITION

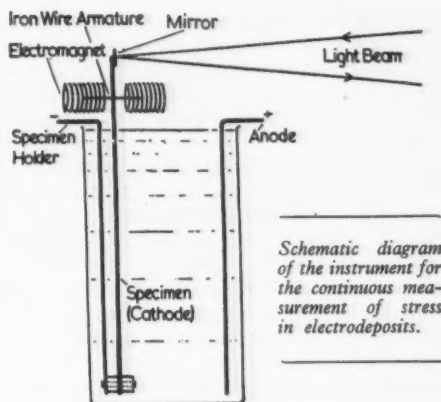
A number of exhibits illustrative of the themes of some of the papers were on show during the Conference period. These included (left, top to bottom) examples of containers used in aerosol spraying (Robert Ingham Clark and Co.); paint adhesion measurement equipment (I.C.I. Ltd., Paints Division); current researches in the Electrodeposition Section of the B.N.F.M.R.A.; samples of plated finishes and results of corrosion tests obtained with the bright tin plating process developed by the Tin Research Institute; examples of opaque coatings produced by chromic-acid anodizing in the course of work at Aluminium Laboratories Ltd.

(Facing page—left to right)—

Semi-automatic paint spraying equipment (Aerostyle Ltd.); hot spraying equipment (The Aerograph Co. Ltd.); airless spray equipment (T. G. Spray Finishing Systems).

prior to plating, it was possible to grind the chromium very severely, with heavy cuts and feeds and without a coolant, without having any effect on the fatigue strength. He agreed with Dr. Hoar in hoping that the equations to which he referred will never get into any specification.

With regard to Dr. Layton's question about internal stress in the steel prior to plating, he fully agreed that any tensile stress in the surface of the steel should be removed prior to cleaning before chromium plating. The easiest way to do that, presumably, was heat treatment. For the detection of very fine cracks before and after plating it might be worth while doing magnetic crack detection, but the cracks were extremely fine, and he doubted whether it would be possible to detect them.



Schematic diagram of the instrument for the continuous measurement of stress in electrodeposits.

Abstract No. 8

An Instrument for the Continuous Measurement of Stress in Electrodeposits

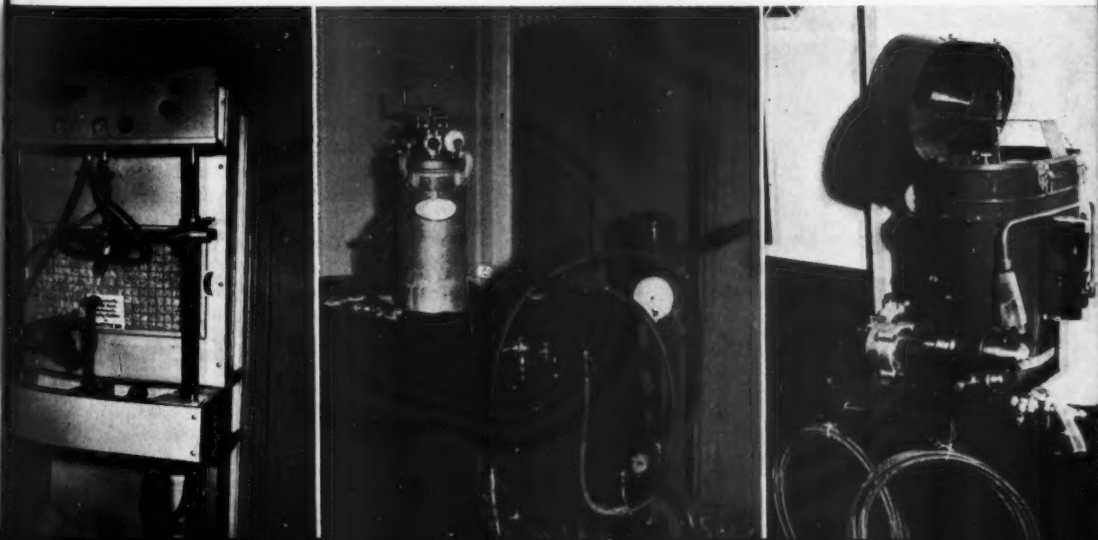
By T. P. Hoar* and D. J. Arrowsmith*

CONTINUOUS methods of stress estimation that involve bending of the specimen have many disadvantages, but all are eliminated when the specimen is kept straight by means of a measured restoring force. If this force is applied to the free end of a straight strip specimen held rigidly at the other, and the deposit is uniform over the surface, the specimen remains straight and does not buckle. This paper describes a "null" instrument based on the above principle, in which the restoring force is electromagnetic and is measured

electrically. There is no mechanical restraint on the free end of the specimen and errors caused by friction are thus avoided. The lower end of a vertical strip cathode is rigidly fixed, and the upper end, projecting through the bath surface carries a light armature of thin iron wire bonded perpendicularly to the surface with adhesive. Solenoids are disposed over each end of the armature, one being used when a tensile stress develops in the deposit and the other when the stress is compressive. Movement of the free end of the strip about the null position in which the strip is straight is observed, greatly magnified, by means of an optical lever operated by means of a small mirror attached to the strip. Both the mean stress in the total deposit and the "instantaneous" stress in the material being deposited at any instant may be very rapidly estimated in terms of the restoring force.

The instrument is in use for the measurement of stress in nickel deposited under a wide variety of

* Department of Metallurgy, University of Cambridge.



conditions, but it is emphasized that the instrument is still undergoing development, and in its present form, being of similar sensitivity to a chemical balance, requires comparable care in operation. Nevertheless, it is already capable of producing results that appear to be more easily interpretable than earlier methods of stress determination.

Discussion

Dr. J. EDWARDS (British Non-Ferrous Metals Research Association, London) said that the authors' method was a comparatively simple adaptation of the bent-strip method, but there was the significant difference that the strip was kept straight and not bent. It was clear from the few experiments reported in the paper that, although the method was capable of further refinement and development, it was already able to give valuable results.

There was no doubt that more and more interest was being taken in the question of stress in electro-deposits and the B.N.F.M.R.A. usually recommended the Brenner and Senderoff contractometer to measure the stress, because that was the method with which the Association was most familiar. He was prepared to defend that choice on the grounds that it was a robust instrument, and also easy to operate. These were perhaps the most important properties required, given a certain degree of accuracy, in instruments for use in production control, and not to be despised by the research worker either. The B.N.F.M.R.A. made a good deal of use of contractometers and to date were fairly well satisfied with them.

The authors set out on page 2 of their paper four disadvantages of methods which relied on the bending of strips. It seemed to him that without further comment these points might be a little misleading. For example, in the first the authors wrote: "Bending must be small, so that the basis metal is not strained beyond its elastic limit." He did not think that this was a great practical difficulty. The established methods were designed for the measurement of small deflexions within the elastic limit, and in any case to produce larger deflexions than that it was usually necessary to apply deposits which were thick in relation to the strip, and these were obviously undesirable for other reasons.

The second point, that "The Young's modulus of the basis metal must be known for the calculation of the stress in the deposit," was true in that the modulus appeared in the equation of stress, but the value of Young's modulus need not be assumed in deriving stress values, because the strip could be calibrated directly by weighting the end of the strip and measuring the deflexion, and this could be done very easily with the contractometer.

He agreed with the other two points, that the

mechanics of the bending strip were difficult, and that bending allowed relaxation of the stress in the deposit, though the question of relaxation could be taken into account, and, although the mathematics of it might not be convincing, so far the results appeared to be satisfactory. What no one would deny was the desirability of making comparisons between a bending-strip method, such as the contractometer method, and a null method such as had been described, and he hoped that the authors would be able to make such comparisons.

As regards the instrument itself, how accurately could the solenoids be adjusted in relation to the strip and armature? Was it possible to adjust them to the same relative position and could specimens be reproduced sufficiently accurately for the instrument to be used without recalibrating it between each determination? Had the authors done enough experiments to be able to say anything about the reproducibility of results? Dr. Hoar had said that many more experiments had been done since the paper was written. He was surprised to read that the specimen did not buckle in the course of the determination; he would have thought it inevitable, since part of the strip was plated and part was not, that some kink should appear. It might be very slight, and perhaps negligible; but if not, that might be a further argument in favour of reducing the distance between the armature and the top surface of the solution.

Degree of Sensitivity

It would be interesting to know what was the limit of sensitivity of this instrument. For some purposes, such as measuring the relief of stress which occurred when just a few cracks appeared in a plated coating, the bent-strip methods were perhaps not sensitive enough, but this instrument might be. He imagined that the difficulties would lie in the elimination of external disturbances.

Many plating processes operated ineffectively, if at all, in the absence of agitation, which was often required to be vigorous and random. In the present form of the apparatus, it was probably only the smoothest and gentlest of agitation which could be permitted, and some arrangement to damp out vibration when required would be of great advantage. Controlled agitation was necessary not only in order to simulate industrial conditions and produce good deposits but because it helped in the attainment of equilibrium conditions. Without agitation the cathode layer might change in thickness and composition over a very long time, and in certain conditions it might be possible to complete a whole experiment without ever reaching the stable conditions which made it possible to make the comparisons which the experiment required. This might give a simple explanation of some of the authors' results, and particularly the variations in

instantaneous stress shown in Fig. 4b. Would these variations in instantaneous stress be related to variations in the rate of incorporation of the addition agent into the deposit rather than to the accumulation of a cathodic reduction product?

Mr. T. E. SUCH (Ionic Plating Co. Ltd., Birmingham) said that the apparatus which the authors described was an improvement on the past methods developed for stress determination inasmuch as the strip did not bend, and so the stress in the deposit could be very high without causing any permanent deformation of the basis metal which would make the results of the experiment useless. This meant that it was possible to determine the stress in quite thick deposits of highly stressed nickel and chromium on the same thickness of strip as used to determine the stress in low stress deposits such as copper and zinc. If conventional methods were used and the strip was allowed to bend, it was necessary to keep changing the thickness of strip to suit the deposit; for instance, with the thickness of steel strip which the authors used it would not be possible to plate more than about 0.00004 in. of chromium without getting permanent deformation. There seemed to be no such limiting thickness with the authors' apparatus, which was certainly an advantage.

No errors were introduced by assuming the Young's modulus, and that was certainly a good point; although, as Dr. Edwards had pointed out, it was possible to determine the Young's modulus quite easily for the basis metal, it was not so easy to do it for the deposit. It was possible to obtain the values in the literature, but they were usually for wrought metals only, and there might be a large error in assuming that they held for the deposits. However, he noticed that the authors stated that for thick deposits the Young's modulus must be known for both metals. What order of thickness had they in mind?

In their description the authors said that their

formula only holds if m , the length from the support, was not very much greater than S , which was the actual length plated. In the model described in the paper m was nearly double S . What was the ratio of m to S in the new model which the authors were developing?

Mr. Such was particularly interested in the curves obtained for instantaneous stress, in particular the one for naphthalene trisulphonate, because he had found the same thing happening with saccharin. It was necessary to work a new solution containing saccharin before any stress-relieving action was obtained.

Did the authors consider that the present form of their apparatus was sensitive and accurate enough to make the values for increasing tensile stress after switching off the current really significant?

Mr. C. WILLIAMS (Armament Research and Development Establishment, Sevenoaks) referred first to an operational point concerning the method of calibration. He understood from what was said on page 3 that the strip was held horizontally during calibration, and with such a thin strip he would have thought that there would be an appreciable deflexion of the strip before applying the weights. He was also surprised, with such a thin strip, that the coating of wax did not affect the deflexion in any way. Did the authors confirm this by calibration tests with the wax on, by deflecting in both the positive direction and the negative direction?

From an engineering point of view he felt that a stress of less than 1 ton per sq. in. was not worth worrying about; but doubtless from the chemical point of view changes of 100 lb. per sq. in. or less had to be watched. As had been pointed out, the main advantage of this instrument would be for research on small changes of stress where the stress could be followed during deposition without there being the stress relief which normally occurred on bending. Apart from this, however, and bearing

Mrs. and Mr. A. F. Berk (director, F. W. Berk and Co. Ltd.) and Mr. G. H. Jenner (Schori Division, F. W. Berk and Co. Ltd.) being received by the President at the Conference dinner.



in mind the large values of internal stress in which he was interested, was he right in thinking that this instrument for measuring stress used the same basic principle as the bent-strip method, but merely replaced a comparatively robust direct linear measurement with an indirect electrical measurement?

On the use of the instrument, on page 9 the authors said that the reversal of stress during plating could not have been observed by a single measurement of stress after plating. This was agreed, but could not a continuously deflecting strip do just what the electromagnetic method of measurement had done? On similar lines, could not the relaxation effect on storage be detected by the conventional bent strip method? He had noted with chromium deposits a change of internal stress during storage for a week. A simple rigid jig was used and he was able to measure the deflexion quite readily at intervals throughout the week. The change of stress was of the order of 2 tons per sq. in.

Mr. C. I. SNOW (I.C.I. Ltd., Paints Division, Slough) asked the authors whether their apparatus would measure even smaller forces than had been discussed, forces which could be expected to arise in the course of drying a paint film, perhaps a few hundred lb. per square inch. The authors' apparatus in principle could obviously measure such forces, but in any self-balancing equipment it was usual to run into interference vibration and what the electrical engineer called noise, and that might apply in this case as well. Was the authors' experience with their apparatus enough for them to say whether it might work for paint films in the same way that it worked for electrodeposited films?

Mr. D. J. ARROWSMITH replying to Dr. Edwards recommended the use of the Brenner and Senderoff contractometer for production control. The authors' equipment was essentially a research instrument, and

it was being used to compare the different effects which change the stress in electrodeposits.

The main criticism seemed to concern the question of the buckling of the strip, and Mr. Such asked what m/S ratio would be for the new instrument. It was true that with a specimen as long as that depicted by Dr. Pick, if a restoring force was applied the unplated end would in fact bend. This could be reduced by applying the restoring force right at the top of the plated area. This had been tried and it was found that if in fact a deposit was formed on the basis metal, then throughout the deposit itself there was uniform bending, and if the force could be applied right at the top there would be no difficulty over buckling at all. In fact the authors were thinking of designing the next instrument so that the electromagnets themselves could be immersed to a small extent in the solution, so that the restoring force could be applied as near the top as possible.

For the adjustment of the solenoids a feeler gauge was used and the instrument was set up in the same way each time. On recalibrating, it was found that except at the very low values of restoring force, i.e., considerably less than 0.1 gm. where there was a certain amount of scatter, above that the iron itself was fully saturated and there was good reproducibility. The presence of small amounts of impurities was likely to give more change in stress than any error due to the instrument itself.

He agreed that in practice agitation was used to a large extent. The authors used only low current densities, considerably lower than are used in practice, and while in practice at 50 amp. per sq. ft. there might be a shortage of relevant ions in the cathode layer, at lower current densities the need for agitation to remedy this effect was not so great.

(Continued in page 262)



A group of well-known I.M.F. personalities at the Conference dinner, including Mr. Bryn Jones (Finishing superintendent, The Prestige Group Ltd.), Mrs. and Mr. Frank Wild (technical advisor, R. Cruickshank Ltd.), Mrs. W. Stein, Mr. and Mrs. A. G. Benning (general manager, Harshaw Chemicals Ltd.) and Mrs. B. J. Jones.

FINISHING

NEWS REVIEW

IMF INAUGURATES NEW BRANCH OFFICERS ELECTED AT BRISTOL MEETING

A LUNCHEON at the Grand Hotel, Bristol, on June 4, was held by the Institute of Metal Finishing to mark the inauguration of the new Bristol and South West Branch of the Institute. Mr. R. A. F. Hammond, President of the Institute, presided at the function, supported by the Hon. Secretary, Dr. S. Wernick.

Some 100 persons attended the luncheon, representing most of the important sections of industry in the West Country, notably the aircraft, general engineering, printing, and paint industries. Numbers of members of the Institute from the London Area and from the Midlands were present, together with a small Northern contingent and one member from Sweden.

Following the luncheon, a party of members visited the Filton Works of the Bristol Aeroplane Co. Ltd., by kind permission of the management. Visitors were shown the process departments in which several interesting special applications of electrodeposition had been developed and were being used in production. The party was also afforded the opportunity of seeing the Bristol Britannia in various stages of construction, the visit culminating with a close-up view of the completed aircraft.

The formal inaugural meeting was held in the evening at the Grand Hotel, Bristol, and was attended by over 100 people. The President opened the proceedings with a short address, in which he briefly reviewed the history of the Institute, and expressed the pleasure of the Institute's Council at the proposal to form the new branch.

On the proposal of Dr. Wernick, seconded by Mr. F. Wild, chairman of the Midlands Branch of the Institute, the following members were elected as officers and committee of the branch: Chairman, Mr. N. R.

Laben, Laboratory Superintendent of the Bristol Aeroplane Co. Ltd.; Hon. Secretary, Mr. J. Dixon, technical representative, M. L. Alkan Ltd.; Hon. Treasurer, Mr. R. T. Poeton, director, A. T. Poeton and Son Ltd.; Committee: Mr. L. A. J. Lodder, technical sales service, Imperial Smelting Corporation Ltd.; Mr. S. Dawson, chief chemist, John Hall (Paints) Ltd.; Mr. J. B. Lane, managing director, Gloucester Plating Co. Ltd.; Mr. H. L. Watts, chief chemist, Armstrong Siddeley (Brockworth) Ltd.; Mr. R. Wilding, process superintendent, Bristol Aero Engines Ltd.

Following his election, Mr. Laben was formally conducted to the Chair and received his badge of office from the hands of the President. He then proceeded to initiate a technical session by introducing the speaker, Mr. L. A. J. Lodder, who presented a paper on "Recent Developments in the Finishing of Zinc Alloy Die-castings". The presentation of the paper was followed by an animated discussion, which afforded ample evidence of the interest with which it had been received.

Apprenticeship in Metal Finishing

FOLLOWING the decision to set up a National Joint Council to administer an apprenticeship scheme in metal finishing, which was reached at the end of last year by a meeting of representatives of interested trade associations, a representative council has now been formed as follows: Mr. A. E. Abbott, Mr. P. S. L. Southall and Mr. C. Wharrad, representing the M.F.A., Dr. J. E. Garside and Mr. H. A. Manning, representing the I.M.F., Mr. Maxwell Lewis representing the S.M.M., and T., Mr. W. Washbourne representing the Zinc Alloy Diecasters' Association, Mr. B. Pulsford, the Name Plate Manufacturers, Mr. L. Ambrose, the A.E.U., and Mr. R. H. Cleaver, the National Society of Motor Mechanics.

At a recent meeting of the Council, Dr. Garside was elected chairman, and Mr. Abbott, deputy chairman. Mr. P. Burns Farquhar, secretary of the M.F.A., will act as secretary to the Council from his office at 27 Frederick Street, Birmingham, 1.

Among the matters agreed by the Council were the form of indenture for apprentices, and the application form for use by employers when seeking registration. Copies of these forms can be obtained from the Secretary.

All applications from employers for registration as being approved by the Council to accept apprentices under the scheme, which are received before the end of this month, will be given consideration in time for approval to be given before the end of the present school year, thus enabling them to take advantage of the peak availability of school leavers.

GAS TURBINE DRIVES AIR COMPRESSOR

AN experimental gas-turbine-driven compressor set has been built for development work by Alfred Bullows and Sons Ltd.

The power unit is the Rover IS/60 gas-turbine engine with an output of 60 B.H.P. and the compressor is the R4000 series Hydrovane sliding-vane rotary unit. The turbine runs at

46,000 r.p.m. and an integral gear-box reduces this to 3,000 r.p.m. at the take-off shaft. Bleed-off air at three atmospheres is taken from the centrifugal compressor of the gas turbine and, after cooling, is fed to the compressor, which in turn compresses it to 100 lb./sq. in. gauge pressure. At this pressure the air compressor will deliver approximately 300 cu. ft. per min.

At present the assembly merely consists of the engine and compressor

and as such was shown at this year's British Industries Fair. In as much as the unit is at present purely experimental, no attempt has been made to mount it as a portable unit, however, it is significant that the combined weight of the engine and compressor is approximately 500 lb. only.

It may readily be seen from this that the weight of a finished unit would be only a very small fraction of that of a conventional 300 cu. ft. per min. machine.



COATED ABRASIVES

English Abrasives Formally Open

WITH the opening of new plant at the Tottenham subsidiary of the English Abrasives Corporation the firm expects to improve both the output and quality of its products and to increase its hold in the export field, especially in the United States.

At the formal opening recently, Mr. G. R. Wolfe Barry, joint managing director of the corporation, outlined the history of its Tottenham branch, London Abrasives Ltd., and its connection with the other two associates, Thomas Goldsworthy and Sons Ltd., Manchester, and Helvetia Abrasives Ltd., Leicester. The group manufactures coated abrasives under the well-known "Britannia" and "John Bull" trade marks.

Founded originally by a Hanover firm, London Abrasives Ltd. started business in Clerkenwell in 1894, moving to Tottenham at the early part of this century.

The firm pooled its technical resources with Goldsworthy and Sons in 1955, although an agreement to operate jointly a grain crushing plant had been in effect since about 1939.

Mr. E. L. Few, the chief engineer and a director of English Abrasives, then took up the story to tell how work on the new plant had begun in 1955 after considerable research into manufacturing methods both on the Continent and in the United States.

Mr. Few has himself worked both in Germany and the United States and his experience has helped to ensure that when development began the latest technical know-how was assimilated in the new plant.

London Abrasives' design engineers, starting from scratch, prepared plans for the construction of machines to be built by various contracting firms working to instructions.

The result is the Tottenham installation, occupying a three-storey building specially adapted to accommodate it, and able to make waterproof and resin-bonded abrasives using special adhesives by the newest methods.

Plant Layout

Good quality abrasive material demands a high degree of control over such factors as a variable output speed, the temperature used in curing and uniform thickness in application of the adhesive coating. Small variations in coating and curing make a big difference to the finished product.

The main section of the new machinery is accommodated on the first

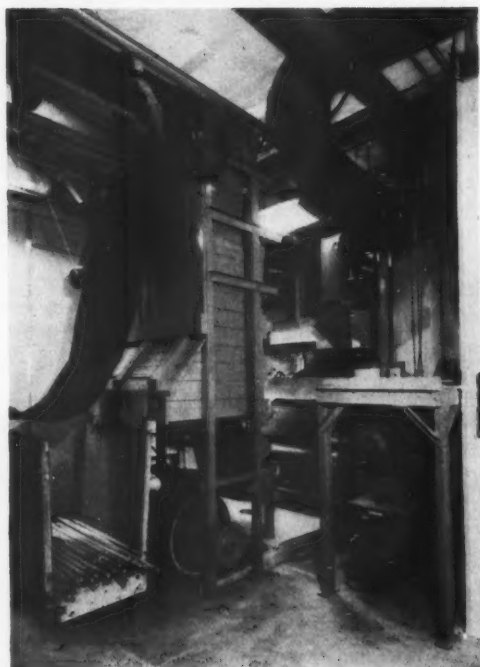


Fig. 1 (left).—
Sizing unit.



Fig. 2 (below).—
Heating humid-
ifying and
extraction plant



PLANT COMPLETED

New Wing to Tottenham Factory

floor of the building, the ground floor being used for housing the return grain system, the elevator, and the supply cabinet for the high-voltage electrical equipment. On the top floor are the heating components used in curing.

No driving belts are to be seen in the plant, all the components of the main machine being driven by synchronous motors that keep individual units in step with the rest of the group throughout a wide range of speed.

On the first floor, close to the main machine, is the mixing room where the resins and adhesives are prepared.

The mixing room is under the close supervision of the chemical department whose frequent checks enable an exact specification to be constantly maintained.

Manufacture

The manufacturing process can be divided into six main stages.

The first unit receives the incoming roll of paper or cloth to print the backing and spread a scrupulously-gauged adhesive layer over its surface.

After this the roll is turned so that its adhesive surface is on the underside and it then moves to the second stage where the roll passes across the milled abrasive grain.

Here, a very high-voltage electrical current is used to induce one electrostatic charge in the grain and another of opposite sign in the roll of adhesive.

The grain particles are projected on to the adhesive surface of the roll by the attractive force of the current, and because each grain carries an electrical charge of like sign, spacing of the abrasive particles on the roll is also uniform.

From here the coated roll is festooned for primary curing and when this has been completed a sizing unit spreads a top coating over the abrasive surface to bind the grain.

The last stage before cutting and reeling is the final curing. For this, lengthy exposure to critically-controlled high temperatures is important and to achieve this a complex heating and fan system handling several tons of heated air a minute is passed along ducts mounted within racks on which the abrasive roll is festooned.

Control Equipment

Temperatures above the boiling point of water are used in the manufacturing process and control of these is vitally important.

Multiple banks of recording instruments regulate and make a permanent record of the heat and humidity conditions during the cycle of operations.

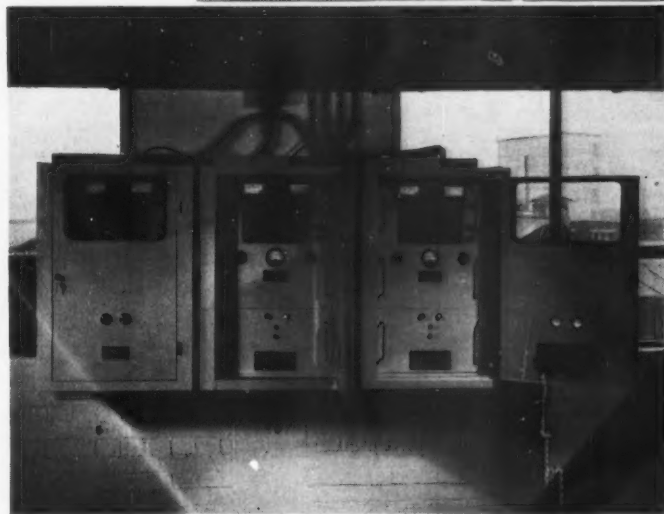
Beta-ray equipment is used to record and control the weight of the adhesive coating on the roll.

In this way complete uniformity in quality control has been achieved.



Fig. 3 (right).—
Making unit and
control unit for
main rack, heating
and humidity.

Fig. 4 (below).—
Part of the beta-
ray control equip-
ment.





COATED ABRASIVES

English Abrasives Formally Open

WITH the opening of new plant at the Tottenham subsidiary of the English Abrasives Corporation the firm expects to improve both the output and quality of its products and to increase its hold in the export field, especially in the United States.

At the formal opening recently, Mr. G. R. Wolfe Barry, joint managing director of the corporation, outlined the history of its Tottenham branch, London Abrasives Ltd., and its connection with the other two associates, Thomas Goldsworthy and Sons Ltd., Manchester, and Helvetia Abrasives Ltd., Leicester.

The group manufactures coated abrasives under the well-known "Britannia" and "John Bull" trade marks.

Founded originally by a Hanover firm, London Abrasives Ltd. started business in Clerkenwell in 1894, moving to Tottenham at the early part of this century.

The firm pooled its technical resources with Goldsworthy and Sons in 1955, although an agreement to operate jointly a grain crushing plant had been in effect since about 1939.

Mr. E. L. Few, the chief engineer and a director of English Abrasives, then took up the story to tell how work on the new plant had begun in 1955 after considerable research into manufacturing methods both on the Continent and in the United States.

Mr. Few has himself worked both in Germany and the United States and his experience has helped to ensure that when development began the latest technical know-how was assimilated in the new plant.

London Abrasives' design engineers, starting from scratch, prepared plans for the construction of machines to be built by various contracting firms working to instructions.

The result is the Tottenham installation, occupying a three-storey building specially adapted to accommodate it, and able to make waterproof and resin-bonded abrasives using special adhesives by the newest methods.

Plant Layout

Good quality abrasive material demands a high degree of control over such factors as a variable output speed, the temperature used in curing and uniform thickness in application of the adhesive coating. Small variations in coating and curing make a big difference to the finished product.

The main section of the new machinery is accommodated on the first

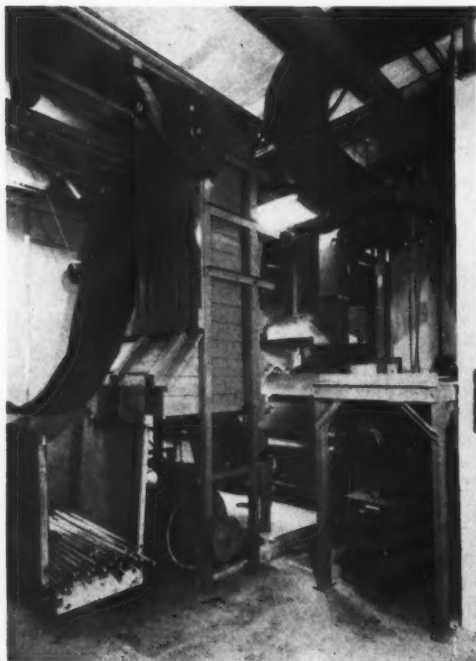


Fig. 1 (left).—
Sizing unit.

Fig. 2 (below).—
Heating humid-
ifying and
extraction plant



PLANT COMPLETED

New Wing to Tottenham Factory

floor of the building, the ground floor being used for housing the return grain system, the elevator, and the supply cabinet for the high-voltage electrical equipment. On the top floor are the heating components used in curing.

No driving belts are to be seen in the plant, all the components of the main machine being driven by synchronous motors that keep individual units in step with the rest of the group throughout a wide range of speed.

On the first floor, close to the main machine, is the mixing room where the resins and adhesives are prepared.

The mixing room is under the close supervision of the chemical department whose frequent checks enable an exact specification to be constantly maintained.

Manufacture

The manufacturing process can be divided into six main stages.

The first unit receives the incoming roll of paper or cloth to print the backing and spread a scrupulously-gauged adhesive layer over its surface.

After this the roll is turned so that its adhesive surface is on the underside and it then moves to the second stage where the roll passes across the milled abrasive grain.

Here, a very high-voltage electrical current is used to induce one electrostatic charge in the grain and another of opposite sign in the roll of adhesive.

The grain particles are projected on to the adhesive surface of the roll by the attractive force of the current, and because each grain carries an electrical charge of like sign, spacing of the abrasive particles on the roll is also uniform.

From here the coated roll is festooned for primary curing and when this has been completed a sizing unit spreads a top coating over the abrasive surface to bind the grain.

The last stage before cutting and reeling is the final curing. For this, lengthy exposure to critically-controlled high temperatures is important and to achieve this a complex heating and fan system handling several tons of heated air a minute is passed along ducts mounted within racks on which the abrasive roll is festooned.

Control Equipment

Temperatures above the boiling point of water are used in the manufacturing process and control of these is vitally important.

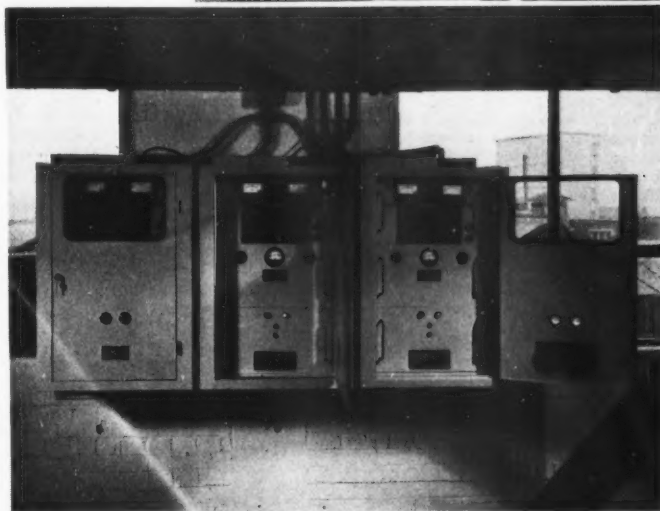
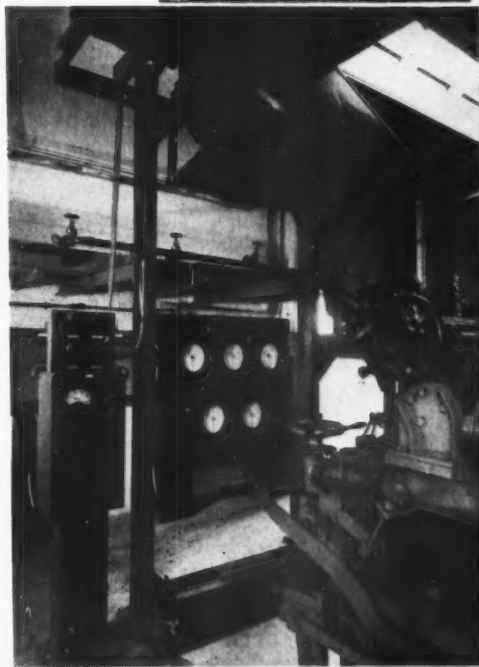
Multiple banks of recording instruments regulate and make a permanent record of the heat and humidity conditions during the cycle of operations.

Beta-ray equipment is used to record and control the weight of the adhesive coating on the roll.

In this way complete uniformity in quality control has been achieved.

Fig. 3 (right).—
Making unit and
control unit for
main rack, heating
and humidity.

Fig. 4 (below).—
Part of the beta-ray
control equipment.





COMPANY NOTES AND NEWS

In order to keep pace with the growing demand for "Airflo" products including P.V.C. fans, hoods and ducting, ventilators, welding tables and dust collectors, **The Industrial Fan and Heater Co. Ltd.**, of Birmingham 11, a member of the Simms Group of Companies, has opened a new branch works at Dawley Brook, Stourbridge, Worcestershire.

By a recently concluded agreement, **Durham Raw Materials Ltd.**, 1-4 Great Tower Street, London, E.C.3, are now selling agents to all industries other than ceramics and refractories, for the clays produced by **Watts, Blake, Bearn and Co. Ltd.**, Newton Abbott, Devon. Much technical research on clays and their properties and uses has recently been carried out by the latter company, largely directed towards the ceramic industry, but the requirements of the paint, rubber and plastics trades in particular are covered by the laboratories of the Durham Group and a close liaison between the two Companies at technical as well as commercial levels is maintained.

The firm of **Ralph Lawton Ltd.** has been registered as a private company with a capital of £15,000 to produce and process ground quartz sands and other minerals for the vitreous-enamelling, polishing, abrasive and other industries. Directors are W. Ralph Lawton and D. B. Lawton.

Adams and Cunat, 973 Rivadavia, Buenos Aires, who are agents of **Jenolite Ltd.**, London, are now manufacturing the complete range of Jenolite products and processes in Argentina.

By an agreement made recently between **Keith Blackman Ltd.**, Mill Mead Road, London, N.17, manufacturers of "Tornado" fans, including mechanical draught and grit arrester types, and **Prat-Daniel (Stanmore) Ltd.**, Whitecroft, Nailsworth, Stroud, Gloucestershire, manufacturers of multi-tubular dust collectors, both companies will be able to

TRADE and TECHNICAL PUBLICATIONS

"Platinum Metals Review": The second number of this new publication from Johnson, Matthey and Co. Ltd., Hatton Garden, London, E.C.1, contains a number of articles relating to industrial uses of the platinum metals. A brief abstract is included from a paper describing the use of a platinum catalyst for the combustion of fumes from enamelling ovens. This is an effective method of dealing with oven effluents as the exhaust fumes are oxidised at a temperature of about 5000° F.

"Efco-Udylite Review": A newcomer on the scene of trade publications is this review published by Electro-Chemical Engineering Co. Ltd., Sheerwater, Woking, Surrey. This company distributes in Europe and the British Commonwealth the electroplating processes, chemicals and equipment of the Udylite Corporation in Detroit, and the review consists of extracts from the News Letters which are sent out periodically to all Efco-Udylite distributors. This first issue provides a very effective cross section of news from abroad and developments in plant and processes.

Nickel: The Nickel Bulletin, the monthly summary of current information published by the Mond Nickel Co. Ltd., Thames House, Millbank, London, S.W.1, contains in its May issue abstracts of papers presented at the recent Brighton Conference of the Institute of Metal Finishing.

Among the abstracts relating to heat and corrosion resistant materials are reports on the use of electrodeposited

coatings for protection of molybdenum from oxidation; coatings examined included, chromium, nickel, gold, chromium-iron alloy, cobalt-tungsten alloy, and nickel-chromium diffusion alloy.

"Plastic Ducting": Some examples of the use of rigid P.V.C. ducting for fume extraction are illustrated in a leaflet issued by Turner and Brown Ltd., Davenport Works, Bolton. Reference is also made to the range of Turbo-Cyclone P.V.C. centrifugal fans.

"Low Temperature Vitreous Enamels": Some further information on the properties of vitreous enamels firing in the range of 1250 to 1350° F are given in the current issue of *The International Enamelist*, published by The Ferro Corporation, 4150 East 56th Street, Cleveland 5, Ohio. Other articles refer to the enamelling of aluminium foil and of aluminium coated steel, a material which has so far not been made commercially available in this country.

"Priming Systems for Metal": The subject of primers for both ferrous and non-ferrous metals is reviewed in the second of the series of technical bulletins issued by T. and R. Williamson Ltd., Ripon, Yorks. The bulletin deals in some detail with the correct preparation of metal surfaces and makes recommendations for full priming treatments on all types of metal. The bulletin is available from the company to any trade of professional enquirer.

OBITUARY

Walters: The death occurred unexpectedly recently, at the age of 66, of Mr. W. Ivan Walters, founder, chairman and managing director of The Walterisation Co. Ltd.

After early experience in the automobile industry, Mr. Walters engaged in experimental and development work with his brother, as a result of which they took out a patent for an improved method of phosphating in France in 1932. The English company, to promote the process, was set up in 1936, and Air Ministry approval for the process led to its widespread use in the aircraft industry during the War. During the post-war years the company made steady progress under the guidance of its chairman, and his friendliness, wise counsel and sound advice, will be sorely missed by those whom he has left behind to carry on the traditions which he fostered.

Technical and Industrial Appointments

Following the retirement of Mr. Walter Wehtje after seventeen years as managing director of the **Atlas Copco Group**, his successor has been named as Mr. K. Allan Belfrage, who was appointed deputy managing director of the Group in 1955.

Mr. Belfrage was 22 when he joined the Swedish Foreign Service and for six years served in various embassies in Europe and America. From 1936 to 1938 he was Private Secretary to the Swedish Foreign Minister. In 1943 he was First Secretary in London and for two years was Political Representative to the French National Committee of Liberation in Algeria. Before joining the Atlas Copco Organization in 1954 as managing director of the French company, Allan Belfrage was Sweden's Envoy to Vienna.

The following staff changes have been announced by **British Titan Products Co. Ltd.**

Mr. R. W. Ancrum, formerly technical director, left the service of

Mr. Kurt Allan Belfrage



the company on April 30, 1957, to take up another appointment.

Mr. S. G. Tinsley, formerly general sales manager, is appointed technical controller of the company, responsible for the company's technical activities, including production.

Dr. P. A. Lintern, formerly production manager, is appointed overseas controller of the company, responsible for overseas projects and undertakings.

Dr. A. Bowman, formerly export sales manager, will take up special duties in the technical organization of the company at Billingham.

Mr. L. W. Robson, formerly home sales manager is appointed general sales manager.

Mr. C. N. Taylor, formerly London sales representative, is appointed assistant to the general sales manager and will shortly move to the company's head office in York.

The appointment has been announced of Mr. Arnold W. Lee as managing director of **Norton Grinding Wheel Co. Ltd.** He will succeed Mr. John C. Ewer who, as announced recently, is leaving to take up a new appointment with Norton Company, U.S.A.

Mr. Lee was born in Handforth, Cheshire, and educated at Manchester Grammar School and the Manchester College of Technology. He was first connected with the abrasive industry in 1923 as an apprentice, subsequently becoming grinding wheel specialist with Alfred Herbert Ltd. He was appointed district manager for Norton in Sheffield in 1936, assistant sales manager at Welwyn in March, 1938, and sales manager in 1940. He became a director of Norton Grinding Wheel Co. Ltd. in 1952.

Rocol Ltd., Swillington, Leeds, manufacturers of molybdenum di-



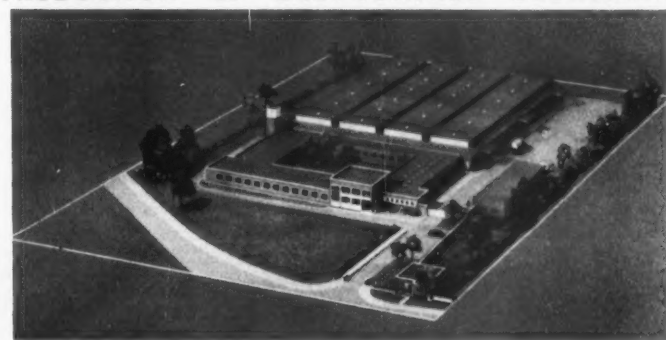
Mr. Arnold W. Lee

sulphide lubricants, have extended their sales department under Mr. John C. Gershon, sales director, with the setting up of a Northern Sales Area, with Mr. S. Lumb as the Northern Area sales manager. The area includes Yorkshire, Lancashire, Durham, Nottinghamshire, Derbyshire and Leicestershire. Mr. Lumb, whose private address is 7 Monckton Drive, Townville, Castleford, Yorks, will work from the Rocol head office at Swillington.

Mr. J. O. Hitchcock, a director of **The Mond Nickel Co. Ltd.**, has been elected a director of **Henry Wiggin and Co. Ltd.**

NEW FACTORY FOR PRODUCTION OF DUST-CONTROL EQUIPMENT

A NEW factory exclusively devoted to the manufacture of dust-control equipment has been opened at Thurmaston, Leicester, by Dallow Lambert and Co. Ltd. Based on a site of 10 acres, the first stage of the complete project has been completed with a building floor space of 56,000 sq. ft. The factory has been designed so that from the "enquiry" to the "completed" stage, work "flows" through the various works departments. Research and development work of a fundamental nature is carried out in a separate building. Although, with the exception of the directors' suite and the conference room above the entrance hall, the new factory is all single storey level, a second floor can be added if required. The photograph on the right shows a model of the completed works.



Surface Treatment of Die Castings

(Continued from page 240)

In the author's opinion, the behaviour in anodic oxidation is mainly dependent upon casting conditions. The pressure die casting process does not ensure a smooth flow of metal into the die, as is the case with gravity die casting or sand casting. Casting under pressure involves a turbulent flow of metal, which makes some oxide inclusions almost unavoidable, and these are largely concentrated in the region of the parting line, and even extensive grinding and polishing cannot altogether eliminate them. The casting skin on pressure die castings should also, for well-known reasons, not be too thin. An approximation to the conditions ruling in gravity die casting can be secured by reducing the injection speed and pressure, but there are limitations to this, and the best results are obtained by liberal gating.

A more regular macrostructure, and with it a more uniform oxide film, could be obtained by heat-treatment (homogenization) but as this involves temperatures above 500°C it cannot in general be employed for aluminium pressure die castings, owing to the risks of warping and blister formation⁽³⁶⁾.

There remains the question whether any improvement in the quality of the anodic film could be obtained by an alteration in the casting procedure. Care should be taken to avoid undue oxidation of the molten metal, and one way of attaining this would be by casting in an atmosphere of neutral gas. Preliminary trials in this direction, using a special die, to produce thin-walled cylindrical castings, have so far led to no conclusive results.

In recent years the vacuum die casting process has been revived⁽³⁷⁾. Whereas previously this process had no great success⁽³⁸⁾, there is now renewed hope that recent advances made in vacuum technique may be applied in the field of pressure die casting. A combination of vacuum melting with vacuum pressure casting might give the desired results in reducing oxidation.

References

- (1) Salje, E. *Werkstatt u. Betrieb*, **86**, (45), p. 177 (1953).
- (2) cf. Bowden, F. P., Tabor, D. Symposium on Properties of Metallic Surfaces, p. 197 (1952).
- (3) Lunn, B. *Z. Metallkunde*, **45**, p. 92 (1954).
- (4) Raether, H. *Z. Physik*, **124**, p. 286 (1948).
- (5) Granel Process of Fisher, G., A.G., Schaffhausen, Switzerland.
- (6) cf. Goldman, H. M. *Proc. A.E.S.*, **37**, p. 223 (1950).
- (7) cf. Fenn, A. P., Lodder, L. A. J. *Proc. Int. Pressure Die Casting Conf.*, London, pp. 54 and 61 ff. (1956).
- (8) cf. *Precision Metal Molding*, **14** (9), p. 87 (1956).
- (9) cf. Bollenrath, F. *Metallüberfläche*, **5B**, p. 85 (1953).
- (10) A very good review of the phosphating of metals is given in a paper by Gilbert, L. O. *Proc. A.E.S.*, **43**, p. 195 (1956).
- (11) Fenn, A. P., Lodder, L. A. J. *Proc. Int. Pressure Die Casting Conf.*, London, p. 62 (1956).
- (12) e.g., the Iridite process of Allied Research Products, Baltimore.
- (13) G. von Giesche's Erben, Breslau. German Patent 671,979 (1936).
- (14) cf. Reininger, H. *Metallüberfläche*, **5B**, p. 76 (1953).
- (15) Caldwell, M. R. *Plating*, **35** (2), 135 (1948).
- (16) Overcash, D. M. *Proc. A.E.S.*, **36**, p. 145 (1949).
- (17) McCahan, R. H., MacKinnon, C. E., Swalheim, D. A. *Proc. A.E.S.*, **35**, p. 203 (1948).
- (18) Blount, E. A. *Proc. A.E.S.*, **38**, p. 49 (1951).
- (19) Nevers, R. P., Hungerford, R. L., Palmer, E. W. *Proc. A.E.S.*, **41**, p. 243 (1954).
- (20) Safranek, W. H., Faust, C. L. *Plating*, **42**, p. 1541 (1955).
- (21) Safranek, W. H., Hungerford, R. L., Palmer, E. W. *Proc. A.E.S.*, **41**, p. 243 (1954).
- (22) Hull, R. O. U.S. Patent 2,149,344 (March 7, 1939).
- (23) Sedusky, H. J., Mohler, J. B. *Metal Finishing*, **45** (1), p. 59 (1947).
- (24) Benner, H. L., Wernlund, C. J. *Trans. Electrochem. Soc.*, **80**, p. 355 (1941). (Also contribution to discussion by Caldwell, M. R.)
- (25) Stephenson, W. G. *Products Finishing*, **20** (4), p. 28 (1956).
- (26) Benner, H. L., Wernlund, C. J. *Trans. Electrochem. Soc.*, **80**, p. 355 (1941).
- (27) British Productivity Report "Metal Finishing", p. 28 (1951).
- (28) A very complete list of references to the literature on the subject is contained in the paper by Ferguson, A. L. and Stephan, E. F. on "The Adhesion of Electrodeposits", published in the *Monthly Review of A.E.S.*, **32**, pp. 894 and 1006 (1945).
- (29) Reinhard, C. E. *Proc. A.E.S.*, **37**, p. 171 (1950).
- (30) Foulke, D. G., Kardos, O. *Proc. A.E.S.*, **43**, p. 172 (1956).
- (31) e.g., Bigge, D. M. S.A.E. preprint No. 51. Nat. Meeting, March, 1953.
- (32) Schaeffer, R. A., Pochapsky, H. *Proc. A.E.S.*, **38**, p. 155 (1951).
- (33) Kronsbein, J., Morton, L. C. *Proc. A.E.S.*, **36**, p. 229 (1949).
- (34) Paulson, C. F. *Plating*, **39**, p. 1330 (1952).
- (35) In recent times direct chromium plating has again been much advocated: cf. Kutzelnigg, A. *Metallüberfläche*, **5B**, p. 156 (1953).
- (36) Anon. *Precision Metal Molding*, **13**, (6), p. 67 (1955).
- (37) Recommended practice for preparation of and electroplating on aluminium alloys. A.S.T.M. Specification B.253 : 53.
- (38) Gutzeit, G. *Revue de l'Aluminium*, **33** (235), p. 805 (1956).
- (39) cf. *Precision Metal Molding*, **14** (9), p. 109 (1956).
- (40) Quandt, R. A. *Die Castings*, **6** (2), p. 36 (1948).
- (41) Federman, A. P. *Precision Metal Molding*, **11** (7), p. 73 (1953); **12** (3), p. 91 (1954); **14** (1), p. 45 (1956); and **14** (9), p. 59 (1956).
- (42) Frommer, L. *Handbuch der Spritzgusstechnik*, p. 229 (1933).

I.M.F. Conference Report

(Concluded from page 256)

There had been criticisms about yielding occurring when bending took place. This was a null method, to avoid any difficulties occurring in the mathematics when bending did take place, but if there was a tensile stress in the deposit there would be, in the basis metal, a certain amount of lateral contraction. This, however, was small and confined only to the interstitial layers.

The specimen, as had been mentioned, was mounted horizontally, and, due to the weight of the strip, it did bend to a certain extent. It was allowed to remain bent to a certain extent, and with one electromagnet mounted in the top weights were added round the armature and the force necessary to keep it in its position, which admittedly was bent, calculated, but it was restored to the same position. The wax affected the deflexion, but here there was the advantage of this being a null method. The specimen was kept straight, and therefore the effects of the wax did not enter into the problem at all.

Mr. Snow had asked whether or not the instrument could be used with paints. As such, no, a deposit was being measured as it formed and not even with the normal bent-strip method was it possible to paint on a film and then measure the stress.

Latest Developments

in

PLANT, PROCESSES AND EQUIPMENT

Electric Spray Gun

WITH a weight of only 3 lb. the Champion "Super" electric spray gun, which projects paint mechanically, is available in this country from S.E.C.A. Ltd., 225 Westminster Bridge Road, London, S.E.1. The gun (Fig. 1) is precision made, and the drive source for the paint is obtained from a robust oscillating electromagnet. By virtue of the very small "mist" produced by the gun it is claimed that it can be used continuously indoors. An easily accessible regulating screw controls the density and area of the spray and this facilitates the achievement of a wide variety of coating finishes. The suction tube in the paint container is angled at its lower end and may be turned to any position so that the gun may be used in any position between the vertical and horizontal. The operating mechanism, which requires alternating-current mains, is contained in a light metal housing to which the insulated handle is attached. The handle incorporates a safety switch fitted with silver-plated contacts. Three different sized nozzles are supplied with the gun which is capable of spraying a wide range of materials. Test reports from a British and a Swiss paint manufacturer are available from the British agents, together with full details of the construction of the gun and recommended operating procedures.

Fig. 1.—Electrically operated spray gun



Rack Coating

A NEW rack coating of the plastisol type has been announced by The Electrochemical Engineering Co. Ltd., Sheerwater Trading Estate, Forsythe Road, Woking, Surrey. In use the rack to be treated is first shot-blasted and then coated with an adhesive which is then stove dried. The rack is then dipped into the cold plastics compound, which has a thick creamy consistency and contains no volatile solvents, and then withdrawn slowly. Stoving is then carried out at a fairly high temperature so converting the plastic into a highly-resistant coating. A second coat is then usually applied to build up a coating thickness of about 3/16 in.

The coating compound is bright yellow in colour so that it can be readily distinguished, and to allow any defects that might develop in service to be seen. The coating can, however, be supplied in other colours if so desired.

Prices and full details of the method of use are available from the manufacturers.

Electromagnetic Filter

THE "Boxmag" Electro-Filter (Fig. 2) is a super-intensity electromagnetic filter designed for the extraction of iron contamination such as fine iron and oxides from powder, granular, and liquid materials in a free flowing or sticky state. This new equipment has a very high efficiency and makes use of a specially-designed magnetic circuit, which induces a high-intensity magnetic field across steel grids in an aperture between the magnet units. The grids are so arranged that the material flowing through them passes freely and at the same time contacts the edges of the grid where any extracted ferrous contamination adheres, allowing the material being treated to flow through unimpeded, and decontaminated. The equipment is designed so that it is easily adapted into chutes or ducting and is arranged so that there is a bleed-off discharge of the extracted ferrous contamination into a breaches chute or suitably arranged container.

The intensity of the field is such that extraction can be carried out at a very high feed rate, and thus the capacity of the separator for its relative size, is high. While free-flowing granular materials can be treated without vibration, the capacity of the machine can be trebled with the addition of a vibrator, which is also essential for the clearance of the extracted ferrous contamination on switching off the equipment. The filter is operated by feeding the material through the aperture and the extracted

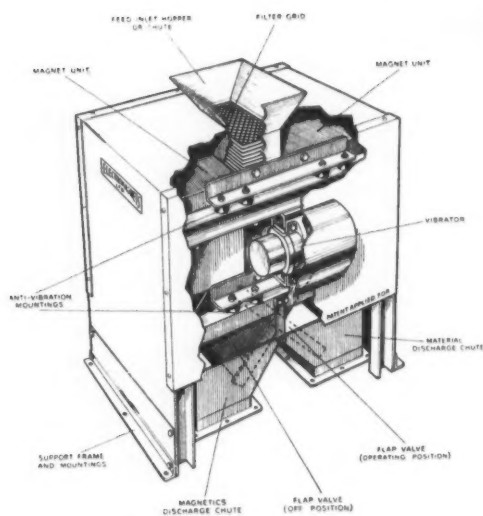


Fig. 2.—Electromagnetic filter

contamination is cleared by switching off the magnet circuit, a flap valve automatically collapsing and deflecting a proportion of the extracted contamination, the grids being completely cleared by the operation of the vibrator, if this is not being used during the whole separation.

The electromagnetic filter is manufactured by Electromagnets Ltd., Bond Street, Birmingham, 19.

Surface Finish Interference Microscope

BECAUSE of the increasing demand for surface finishes of the highest quality and the necessity for precision methods of assessment and control, C. Baker of Holborn Ltd., 244 High Holborn, London, W.C.1, have designed, and are manufacturing, a new surface finish interference microscope.

A high degree of optical and mechanical stability has been achieved in this instrument in two ways:

First, the optical system calls for only a single objective instead of the usual two and the division and recombination of the light beam are confined to the small region between the objective and the specimen. Second, the instrument gains rigidity by departing from the overhung design of the conventional microscope, and incorporates a stage 7 in. diameter which can be lowered to afford a clearance of 5 in. between its top surface and the front of the objective lens.

In use the microscope (Fig. 3) presents a magnified view of the surface under inspection, crossed by a system of equally spaced interference fringes or bands, generated by the optical system of the instrument. With a plain perfectly finished surface in focus the fringes are quite straight but they are deformed if they cross any fine surface flaws such

as grooves, scratches or pits. The shape and extent of the fringe deformation constitutes an exact measurement of the shape and extent of the flaw causing it. The fringe system may be likened to the contour lines of a relief map, and the depth or height of a surface irregularity can be determined by estimating or measuring the corresponding fringe deformation.

The unit of measurement employed is the internationally-recognized wavelength of green light, and as this quantity is not subject to variation, the microscope does not require any outside calibration and always measures correctly.

For photographing surfaces under examination a 35-mm. camera is provided. The scope of the microscope is such that defects as small as one-millionth part of an inch can be measured.

Spray Gun for Unstable Materials

THERE is a growing need in industry for a method of spraying materials of all types which are unstable by nature, which will not tolerate agitation and violent changes of direction of flow and which cannot be readily removed from the spraying equipment by normal cleaning. For this purpose Alfred Bullows and Sons Ltd., Long Street, Walsall, Staffs, have produced the L510 Spray Gun (Fig. 4).

The fluid passage of the gun is a straight tube, (Continued in page 266)

Fig. 3.—Surface finish microscope



1957

tent
exact
flaw
the
a or
ined
dingthe
reen
ion,
sidetion
the
one-or a
which
rate
flow
the
this
reet,
prayube,
(266)

NOT TOO BIG



For Hot Galvanizing

Hot galvanizing is a remarkably versatile rust-proofing process. For buckets, tanks, wire, window frames, bins and countless other items of everyday life, its uses are well known. But few realize how large are many of the articles hot galvanized. Three-storey building stanchions, 2,000-gallon cylinders, road tankers—these things hot galvanizing takes in its stride. But that is not all. Much larger objects are also given long term protection by hot galvanizing the component parts separately and assembling them afterwards. Take the railway goods waggon (bottom left). Measuring 17' 6" long by 8' 6" wide, this wagon is designed for dipping in four parts—an under-frame and three body-sections—which are later bolted together. For T.V. masts the same technique is used. Like all B.B.C. television masts, that at Sutton Coldfield (top right) is built up of hundreds of pre-galvanized sections to ensure the longest possible life without attention. With suitable designing, the sky is the limit!

Hot Dip Galvanizers Association

*The Hot Dip Galvanizers Association,
a non-trading body, welcomes enquiries.*

*Write to 34 Berkeley Square,
London, W.1*

Tel. Grosvenor 6636



Member of the Zinc Development Association

Plant, Processes and Equipment

(Continued from page 264)

end to end, and is normally made of stainless steel, but this can be changed for any required material which can be machined, so that the gun can easily be adapted for use with highly corrosive, abrasive and other difficult fluids.

It will handle all materials requiring an unobstructed fluid passage and will have an immediate application where unstable latex emulsions have to be sprayed, as well as in the ceramic industry where unstable suspensions are commonly found.

The gun is extremely simple in construction, having a bronze body to which can be fitted the complete range of air and material nozzles for the Bullocks L200, 1500 and L600 Spray Guns. Ease of cleaning and general maintenance have been carefully considered in its design and it is suitable for remote control by valves which can be hand, foot, cam or solenoid operated.

Abrasive Finisher for Large Surfaces

AN entirely new machine for abrasive finishing on large flat surfaces which will operate quickly and efficiently on metal, plastic or wood and is economical and efficient on abrasives paper belts, has been developed by Taylor Tools and Supplies Ltd., Atlantic Street, Broadheath, Altrincham.



Fig. 4.—Spray gun

The table surface of the machine (Fig. 5) is a yard square and the whole of this area can be used for polishing.

The contact roll or pad is supported on a rigid bridge and traversed by air hydraulic mechanism, giving an infinitely variable speed. The table feed is automatic and the contact pressure can be varied

(Continued in page 268)

YOURS for the Asking

LEARN HOW TO:—

SPECIFY,

TEST,

USE,

SHERARDIZING

Write to:—

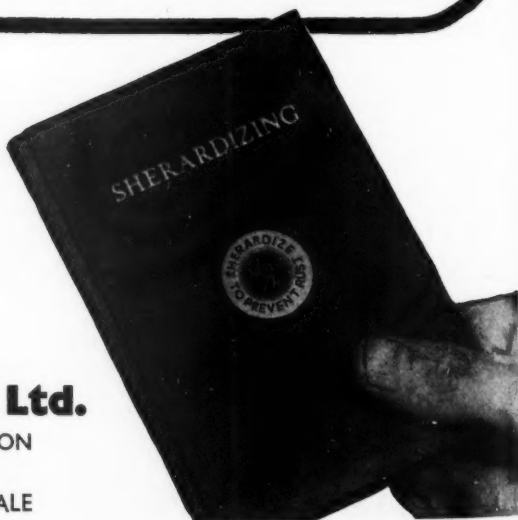
ZINC ALLOY

RUST-PROOFING Co. Ltd.

SHAKESPEARE STREET, WOLVERHAMPTON

Telephone: Wolverhampton 20647/8/9

And at LONDON and ROCHDALE



**The more
intricate the
design the greater
the saving**

Aluminium articles of intricate design can be polished easily and cheaply in Albright & Wilson's 'PHOSBRITE' solutions.

As a complete finish or, alternatively, before plating or anodizing, chemical polishing with 'PHOSBRITE' solutions saves time and money over mechanical methods.

CHEMICAL POLISHING WITH

PHOSBRITE



saves time & money

For full information write to
ALBRIGHT & WILSON (MFG.) LIMITED
METAL FINISHING DEPARTMENT
1 KNIGHTSBRIDGE GREEN
LONDON : SW1

TBW/410



Plant Processes and Equipment

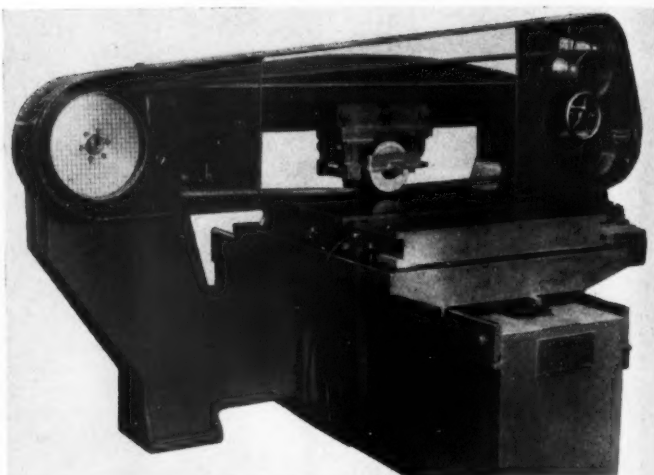
(Continued from page 266)

Fig. 5. — Abrasive belt finishing machine

to suit the materials being processed and the finish required.

In the illustration, the machine is operating with the electro-magnetic clamping provided for surface polishing and finishing of suitable objects. It can be used with other types of securing mechanism as required.

This firm also manufactures a wet belt grinder.



Classified Advertisements

Prepaid rates: FIFTEEN WORDS for 7s. 6d. (minimum charge) and 4d. per word thereafter, or 24s. per inch. Box number 2s. 6d., including postage of replies.

SITUATIONS VACANT

SENIOR SCIENTIFIC OFFICER/SCIENTIFIC OFFICER required by the Atomic Weapons Research Establishment, Aldermaston, Berks, to carry out research and development work on the Electro-deposition of metals. First or second class honours degree (physics or metallurgy) or equivalent qualifications required. Experience in field of metallic coatings or related subjects desirable, but keenness and aptitude for applied research work essential.

Salary: Senior Scientific Officer £1,155—£1,355 p.a. (male).

Scientific Officer to be assessed according to age, qualifications and experience within the scale £610—£1,065 p.a. (male).

Contributory superannuation scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at above address. Please quote ref. A/1428/239.

ROTO-FINISH LTD. seek qualified Chemist or Metallurgist to assist Chief Metallurgist. The work requires a high degree of intelligence and offers unusual scope to investigate and develop a diverse range of new metal finishing methods.

This is not a routine job but is an opportunity for a man with real ability to join a progressive and expanding company. Experience should preferably include at least three years' post graduate work in metal finishing.

Housing can be arranged and the Company provides Life Assurance, Pension, canteen facilities, etc.

Attractive starting salary offered with an annual profit-sharing bonus.

Application should be made in writing and sent in strict confidence to the Managing Director, Roto-Finish Ltd., Mark Road, Hemel Hempstead, Herts.

NOTICE

NORTH STAFFORDSHIRE TECHNICAL COLLEGE
STOKE-ON-TRENT

COLLEGE OF CERAMICS

Principal: H. W. WEBB, O.B.E., D.Sc., F.R.I.C.,
M.I.CHEM.E., F.I.CERAM.

Head of Department: W. L. GERMAN, M.Sc., Ph.D.,
F.R.I.C., F.I.CERAM.

COURSES IN VITREOUS ENAMELLING SESSION 1957-58

Classes begin Monday, September 23rd, 1957.

Interviewing week: September 16th to 20th inclusive.

Full-time Course in Vitreous Enamelling leading to the Manager's Diploma

This is a full-time course of three years' duration on the Sandwich scheme, involving six months full-time study at the College and six months on a works in each year. The course includes VITREOUS ENAMELLING, METALLURGY, ENGINEERING, CHEMISTRY and MANAGEMENT SUBJECTS.

Part-time Course in Vitreous Enamelling

This is a less comprehensive course of three years' duration in VITREOUS ENAMELLING and METALLURGY, intended for those who can only be released from work on two half days each week.

Full-time Course for Diploma in Ceramics

This is a three year full-time course intended for SCIENTIFIC PERSONNEL. The subjects are CHEMISTRY, PHYSICS and CERAMICS (including VITREOUS ENAMELLING).

Specialist Lectures on the Production of Vitreous Enamelled Ware

A series of twelve weekly lectures on the production aspects of vitreous enamelling of sheet steel and castings will be given on Tuesday evenings from 5.15 to 6.30 p.m. commencing on September 30th, 1957. These will be given by well known technologists from the industry.

Further details of the courses can be obtained from the Principal.



METROVICK VACUUM COATING PLANT

Type 27

Combines a fast process cycle with simplicity of controls

Tank size :	27" diameter x 24" deep
Pump-down time (Tank empty) :	4-5 minutes from atmospheric pressure to 10 ⁻⁴ mm. Hg.

Any material, which is stable under high vacuum conditions, can be coated with a metallic film either for decoration or as a functional process.

Typical Applications

Aluminising reflectors for car headlamps, etc.
Deposition of thin coatings of conducting or resistive materials on non-metallic bases.
Decoration of plastics for costume jewellery
— souvenir goods, etc

METROPOLITAN-VICKERS

ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER, 17.

An A.E.I. Company

N/D502

BARREL FINISHING SAVES YOU MONEY

Here's Why *Supersheen*
Barrels Last Longer

Supersheen Barrels are all-welded, heavily gusseted construction to provide extra strength and rigidity—and yet save power costs on operation. Drive chains and sprockets are heavy type to assure continuous performance with very minimum of maintenance. For the best equipment, compare Supersheen Barrels' important design features before you buy.



Write today for 32-page color-log on complete Supersheen production line and services.

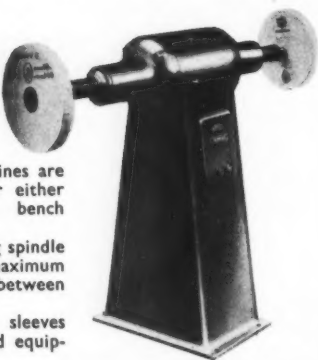
ALMCO Supersheen
Division of Great Britain Ltd.,
Bury Mead Works, Hitchin, Herts

SUPERSHEEN SPEED BARREL FINISHING

CANNING

A. C. POLISHING MOTOR No. 1612

FOUR
BEARING
TYPE FOR
HEAVY
DUTY



These machines are supplied for either floor or bench mounting.

★ A long spindle gives maximum distance between operators.

★ Safety sleeves are standard equipment.

More of these polishing motors are in use today than any other individual type.

CANNING BIRMINGHAM · LONDON & SHEFFIELD

WHY WORRY ABOUT METAL FINISHES ?

We advise without obligation on the best finish for a particular use.

Of course we hope to Electro Plate, Bronze, Anodize or Spray for you and thus solve your problem.

But we may find you the answer elsewhere.

35 years Experience at your service.

YOUR problem interests US

ASHTON & MOORE
(METAL COLOURERS) LTD.,
3, LEGGE LANE, BIRMINGHAM, 1.
Cen. 2234.

QUARTZ & SILICA SANDS

CHEMICALLY TREATED,
GRADED AND GROUND

for the

VITREOUS ENAMEL
POLISHING AND
ABRASIVE INDUSTRIES

RALPH LAWTON

LIMITED

SUTTON STREET,
NEWCASTLE
STAFFS

TEL: 65466

'THREE ELEPHANT BRAND' * BORON PRODUCTS

PYROBOR*

V-BOR*

BORAX

BORIC ACID

From one of the world's largest deposits

delivered fast from U.K. stock



Lithium products too:-

LITHIUM ORES

LITHIUM CARBONATE

LITHIUM HYDROXIDE

* Registered Trade Marks of
American Potash & Chemical
Corporation.



At Searles Lake in the California Mojave Desert, these Boron products are processed by American Potash & Chemical Corporation. They are speeded to you from storage dep ts strategically placed in London, Glasgow, Hull, Liverpool, Birmingham, Wolverhampton and Cardiff.

This super-fast service is handled by Borax & Chemicals Ltd., U.K. and European sales subsidiary of American Potash & Chemical Corporation, Produc rs of: Borax, Soda Ash, Salt Cake, Lithium, Bromine, Chlorates, Perchlorates, Manganese Dioxide and a diversified line of Agricultural and Refrigerant chemicals.

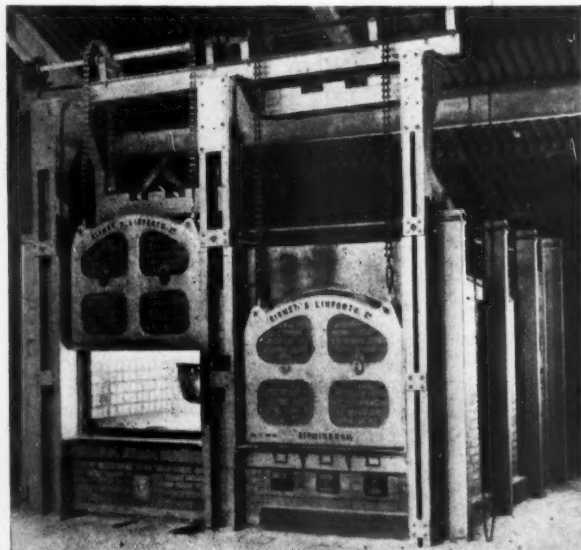
BORAX AND CHEMICALS LIMITED

Kings Bourne House,
229 High Holborn, London, W.C.1.

Telephone: HOL 6518.

Cables: BORAXCHEM LONDON

Agent in Scotland —
McCall & Miller Ltd., 97 Maryhill Rd., Glasgow, N.W.
Telephone: DOUGLAS 0100.



By Courtesy of W. H. MICKLETHWAIT & CO. LTD.

enamelling muffles

BATH MUFFLE

WITH PRE-HEAT

CHAMBER. 2.8 GALS.

OIL PER FINISHED

BATH

SISMEY & LINFORTH

241 ALCESTER ROAD SOUTH · BIRMINGHAM 14

TELEPHONE: HIGHBURY 1369 · TELEGRAMS: SISMEY.BIRMINGHAM.

ELIMINATE . . .**MR. DUST DEVIL!**

For him only the best tack rags are good enough!

* Choice of three degrees of tackiness

* Buy in Cut Bulk or individually packed.

The only Tack-Rag that can work week after week without hardening or drying out!

A.D. TACK RAGS COME FIRST FOR FINISHING

Free samples and booklet on request

A.D. Tack Rags & Adhesive Dusters Ltd.
P.O. Box, 28 Kates Hill, Dudley, Worcs.

Telephone: 4816 Telegrams Add. TAKDUST DUDLEY

ENAMELS

and

FRITS

for

CAST & SHEET IRON

COLOURING OXIDES

MILLING CLAY

RAW MATERIALS



Manufacturers of:

Ceramic Colours, Chemicals, Glazes, Vitreous Enamels, Minerals & Materials for the Pottery, Tile, Brick, Glass & Vitreous Enamelling on Metal Industries

ETRURIA, STOKE-ON-TRENT

INDEX TO ADVERTISERS

	Page		Page
A.D. Tack Rags and Adhesive Dusters Ltd.	28	International Paints Ltd.	3
Aerograph Co., Ltd.	—	Jenkinson, W. G., Ltd.	—
Albright & Wilson (Mfg.) Ltd.	23	Lawton, Ralph, Ltd.	26
Alkan, M. L., Ltd.	29	Main Enamel Manufacturing Co. Ltd.	17
Almco Ltd.	26	Metals & Methods Ltd.	—
Ashton & Moore (Metal Colourers) Ltd.	26	Metropolitan-Vickers Electrical Co. Ltd.	25
Ballard, F. J., & Co. Ltd.	10	Midland Galvanizers Ltd.	1
Bard & Wishart	—	Minnesota Mining & Manufacturing Co. Ltd.	16
Blythe Colour Works Ltd.	2	Morris, B. O., Ltd.	—
Borax & Chemicals Ltd.	27	Partridge Wilson & Co. Ltd.	8
Borax Consolidated Ltd.	18	Penfold Metallizing Co. Ltd.	—
British Chrome & Chemicals Ltd.	12	Pyrene Co. Ltd.	—
British Paints Ltd.	13	Radcliffe, Norman, Ltd.	—
British Titan Products Co. Ltd.	20	Richardson, R. J., & Sons Ltd.	—
Brotherton & Co. Ltd.	—	Roto-Finish Ltd.	—
Canning, W., & Co. Ltd.	26	Shell Chemical Co. Ltd.	15
Cruikshank, R., Ltd.	16	Sismey & Linforth Ltd.	27
Curran, Edward, Engineering Ltd.	4	Stordy Engineering Ltd.	—
Durand & Huguenin S.A.	—	Summers, John, & Sons Ltd.	—
Electro-Chemical Engineering Co. Ltd.	9	Sutton Silica Co. Ltd.	26
Escol Products Ltd.	30	T.C. Spray Finishing Systems	—
Ferro Enamels Ltd.	—	Tex Abrasives Ltd.	16
Gas Council	6 & 7	Volspray Ltd.	11
Glostics Ltd.	14	Wallace & Tiernan Ltd.	—
Griffiths, A. E., (Smethwick) Ltd.	5	Wengers Ltd.	28
Harshaw Chemicals Ltd.	—	Wilkinson, James, & Son Ltd.	—
Hot Dip Galvanizers Association	21	Zinc Alloy Rust-Proofing Co. Ltd.	266
Impregnated Diamond Products Ltd.	14	Zinc Development Association	21

Announcing

ROHCO

SUPER XL

Cadmium Brightener



**for the
most brilliant Cadmium**

1. Gives the clearest and most uniform cadmium deposit yet seen.
2. Has amazingly wide latitude of concentration range.
3. Is supplied as either liquid or powder in highly concentrated form and can be used in vat as well as barrel.
4. Being compatible with most organic cadmium brighteners it can be added to existing solutions after necessary conversion procedure has been carried out.

M. L. ALKAN LIMITED

LONG DRIVE, GREENFORD, MIDDLESEX

Phone: WAXLOW 4541 (3 lines)

Grams: ALKANODE, GREENFORD, MIDD.

BIRMINGHAM OFFICE: HERALD CHAMBERS, MARTINEAU ST., BIRMINGHAM, 2

Phone: MIDLAND 6984

metal finishing

PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING,
GALVANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES.

Founded 1920 as the
INDUSTRIAL FINISHING JOURNAL

Vol. 3 No. 30 (new series)

JUNE, 1953



THE SYMBOL OF SERVICE AND QUALITY

ESCOL FRITS

AND
ENAMELLING EQUIPMENT

ensure
CONSISTENT HIGH QUALITY
PRODUCTION

ESCOL PRODUCTS LTD.

PAISLEY WORKS • SWAINS ROAD • TOOTING JUNCTION • S.W.

Telephone:
MITCHAM 1634 (5 LINES)

Telegrams:
ESCOL • TOOT • LOND

